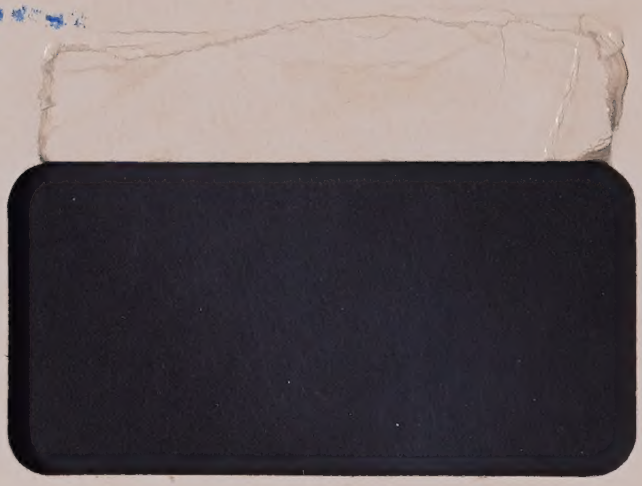
Command Rec.

BERKELEY
FREQUENCY METER

Model 5570

Berkeley division
BECKMAN INSTRUMENTS, INC.
2200 WRIGHT AVE., RICHMOND, CALIF.



WARNING

Do not attempt to operate this instrument until you have read the Instruction Manual.

PROPERTY OF
DEPT 214

INSTRUCTION
MANUAL

Lot 4 and up
Serial 211 and up

SERIAL # 249

BERKELEY
FREQUENCY METER

Model 5570

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
15 February 1954

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Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

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Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.

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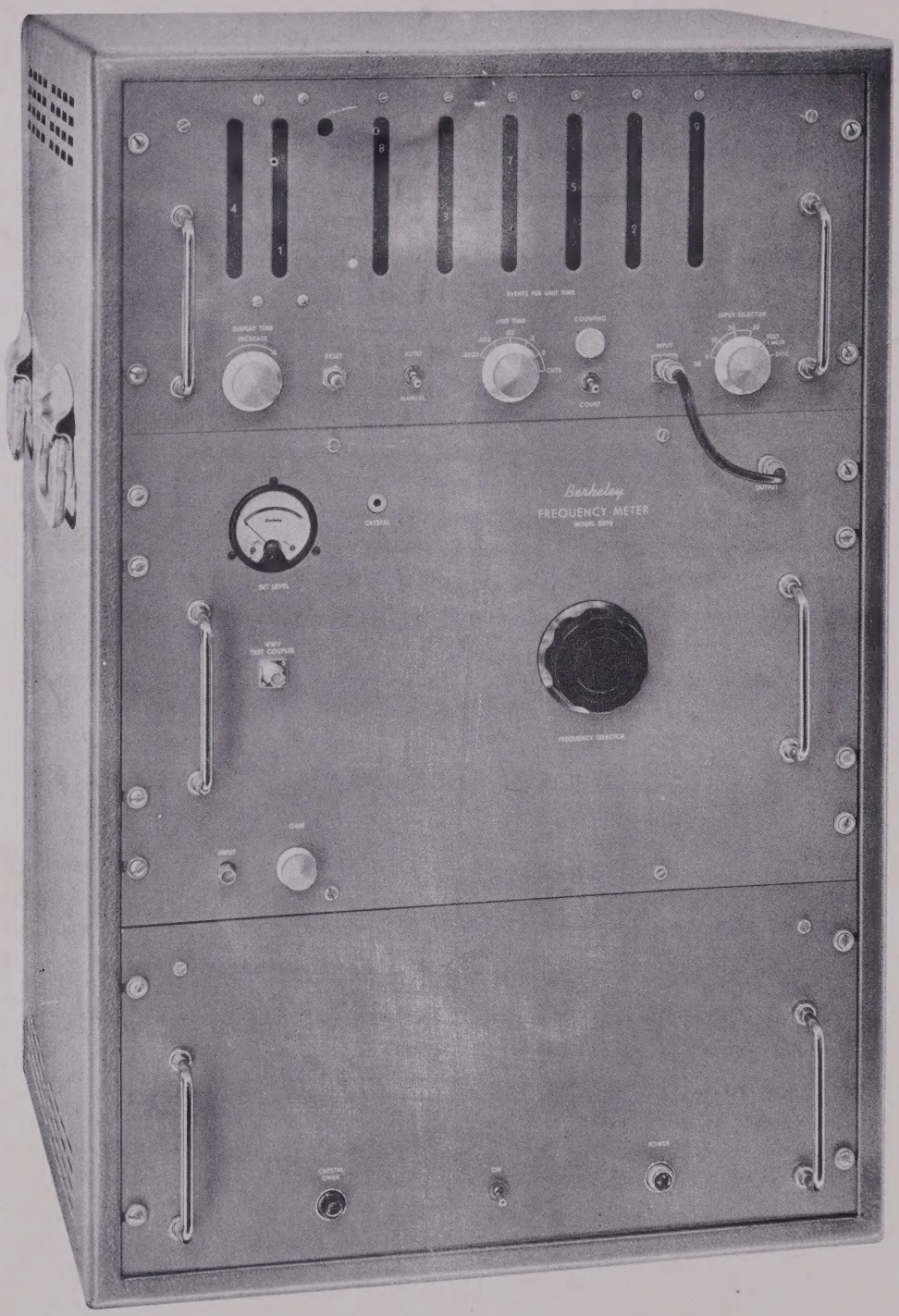


Figure 1 Model 5570 Frequency Meter

Section 1
INTRODUCTION

The Model 5570 Frequency Meter is designed to measure and present in digital form frequencies from 0 to 42 megacycle. Precise measurements, accurate to one part in ten million plus or minus one count, may be obtained with minimum effort.

Basically, the instrument consists of two sections, a crystal controlled Heterodyne unit and a high speed Events-Per-Unit-Time meter. Any unknown frequency may be applied to the Heterodyne unit, passed to the EPUT meter as a frequency of 1 megacycle or less, and displayed on the eight digit EPUT section.

The Heterodyne unit, composed of a 1 megacycle pulse generator and harmonic selector, a mixer, output amplifier, low pass filter, and output level meter, has a large rotary control on the front panel which is used to select any harmonic of one megacycle from 2 to 41 as a reference frequency.

Signals of less than 2 megacycles may be directly injected into the EPUT section. For higher frequencies, the signal is applied at the input jack of the Heterodyne unit where it is mixed with the reference frequency to produce a beat frequency which is applied to the counting circuits.

The EPUT section combines a high-speed electronic counter with an accurate crystal controlled time base. The time base opens and closes an electronic gate for a precise counting interval. This section will accept a maximum of 4,500,000 million pulses in a two second counting interval.

Through synchronization with WWV, the Model 5570 may be quickly and accurately adjusted even during an actual measurement. The overall accuracy is a function of the crystal stability plus the irreducible error of all electronic counting devices, ± one count.

Specifications

Range:	Zero to 42 megacycles/sec.
Accuracy:	±1 count ± crystal error (short term: 1 part in 10^7)
Input Sensitivity:	Not more than 100 millivolts rms.

Input Impedance:	Standard - 100 ohms 100 K on request
Display Time:	1 to 5 seconds continuously variable
Sample Period:	2 seconds
Time Base:	0. 0002, 0. 002, 0. 02, 0. 2, 2. 0 seconds
Power Requirements:	117 volts a-c ±10% 50 to 60 cps at 400 watts
Accessory Sockets:	Connects to Digital Recorder System Coax input socket for use with external reference Coax output socket connects to VHF
Dimensions:	Indicator unit 8-3/4" x 19" x 16" Heterodyne Unit 12-3/4" x 19" x 11" Power Supply 8-3/4" x 19" x 16" Overall 32" x 21" x 19"
Weight:	165 pounds

Accessories

The Digital Recorder System may be used with the Model 5570 to provide a continuous printed record of frequencies measured. By this means, time consuming tests such as frequency vs. temperature may be performed automatically.

Higher frequencies, up to 150 megacycles, may be measured with the Model 5575 Converter. The Model 5575 is connected to the Model 5570 through a socket provided at the 1 megacycle crystal output. Converters capable of measuring up to 500 megacycles may be obtained on special order.

Section 2
OPERATION

Installation

The Model 5570 requires no special installation procedure. It may be operated in any well ventilated location. The unit is designed to operate from an a-c source of 117 volts, 50-60 cps, at a power rating of 400 watts. Satisfactory operation may be expected from 105 to 130 volts. The complete instrument consists of three units, Heterodyne, Indicator, and Power Supply.

The following interconnections should be visible from the rear of the cabinet:

1. Heterodyne unit to J105 on indicator unit
2. Heterodyne unit to J104 on indicator unit
3. J102 of indicator unit to J401 of heterodyne unit
4. Indicator unit to power supply unit
5. Fan (on cabinet) to indicator unit

Operation

To put the instrument in operation, connect the power cord and turn on the POWER switch (see Figure 2 and Table 1). After a five minute warm-up, test the instrument for proper operation:

1. Turn UNIT TIME switch to 2
2. INPUT SELECTOR to TEST 1 MC
3. AUTO/MANUAL switch in AUTO position

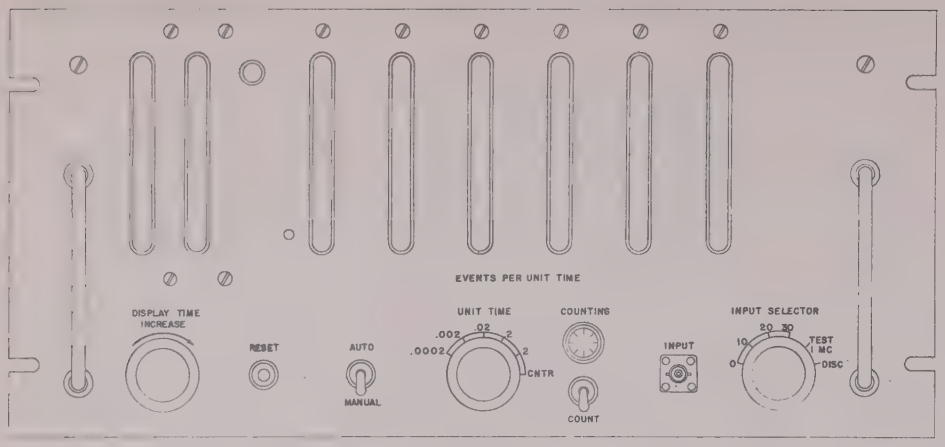
Instrument should read 1,000,000

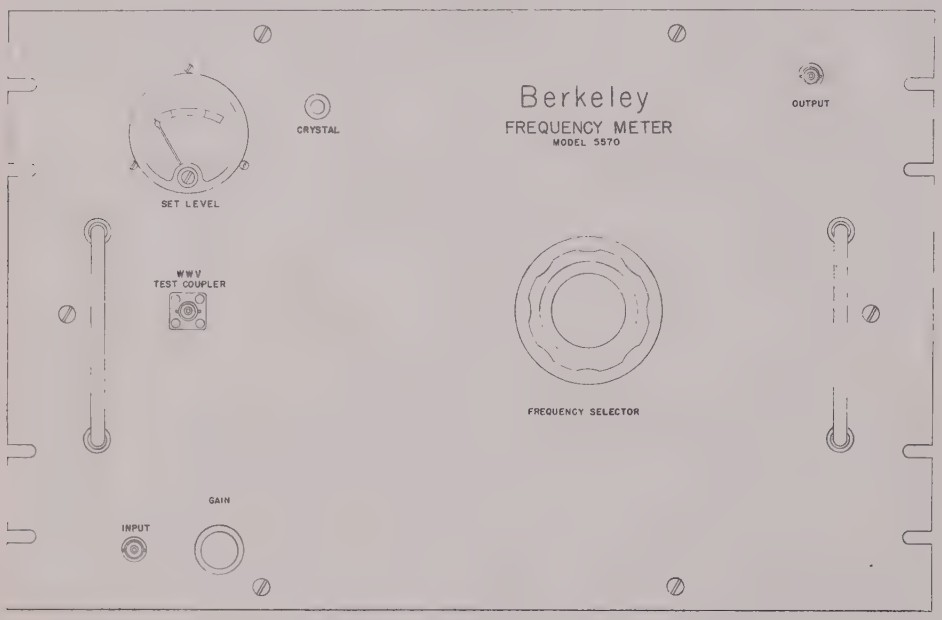
To measure frequencies below 2 MC:

1. Connect unkown signal to INPUT SOCKET of INDICATOR UNIT
2. Turn INPUT SELECTOR to 0, 10, 20 or 30 DB for consistent readings

To measure frequencies from 2 to 42 MC:

1. Connect unkown signal to INPUT of HETERODYNE UNIT and patch across from OUTPUT of HETERODYNE UNIT to INPUT of INDICATOR UNIT. Although the sensitivity is specified as





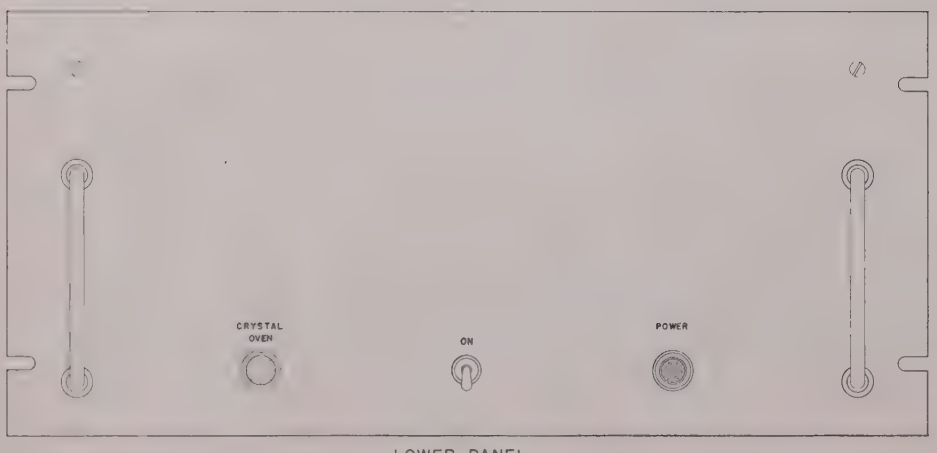


Figure 2 Outline View, Model 5570 Frequency Meter

Table 1
CONTROL & CONNECTOR FUNCTIONS

Control or Connector	Detail No.	Component	Function
		Front Panel	
INPUT	J405	BNC type UG-290/U	Connector for input frequencies above 2 Mc
GAIN	R440	100 ohms 2W Potentiometer	Attenuates input signal
FREQUENCY SELECTOR	Turret Switch	Special Berkeley switch	Selects precision reference frequency
OUTPUT	J404	BNC type UG-290/U	Connector for low frequency beat
INPUT	J101	BNC type UG-290/U	Connector for input frequencies below 2 Mc and low frequency beat from Heterodyne unit
DISPLAY TIME INCREASE	R153	10 ohms 2W Potentiometer	Varies display time
RESET	S105	SPDT toggle switch	Optional manual reset
AUTO-MANUAL	S103	SPDT toggle switch	Optional manual reset
COUNT	S104	SPDT toggle switch	Optional manual reset
UNIT TIME	S102	2-Deck Rotary switch	Selects output from time base dividers
INPUT SELECTOR	S101	5-Deck Rotary switch	Selects input circuit
		Rear Chassis	
EXTERNAL 1 MC. INPUT	J402	BNC type UG-290/U	Connector for use of external 1 Mc standard

Control or Connector	Detail No.	Component	Function
		Rear Chassis	
1 MC OUTPUT	J401	BNC type UG-290/U	Connector for precision 1 MC output (for use with accessories)
HETERODYNE UNIT J104	J104	AN 3102 A-18-S-1S	Power supply for heterodyne unit
HETERODYNE UNIT J105	J105	AN 3102 A-20-27S	Connector for control lights
FAN	J106	CINCH Receptacle	Line voltage for fan
INPUT 1 MC J102	J102	BNC type UG-290/U	Connects precision 1 MC from Heterodyne UNIT for time base synchronization
DIGITAL RECORDER J103	J103	AN 3102 A-18-12S	Connects to Berkeley Model 1556 Digital Scanner

100 mv rms the instrument is considerably more sensitive than this over a major portion of its range. When searching for an entirely unkown frequency, keep the input level at about 100 mv to avoid ove drive.

2. Set INPUT SELECTOR to 0 DB

3. Turn Frequency Selector in a clockwise direction from a value known to be below the frequency to be measured until the level meter shows a marked deflection. Set level meter in green region by adjusting gain.

4. Read final answer on Indicator unit

Calibration of internal crystal. Simultaneously, connect the WWV TEST COUPLER and an external antenna to the input of a communications receiver. Set the crystal frequency by varying the trimmer capacitor on the front panel until a zero beat is obtained on WWV frequencies of 5, 15, 20 or 25 megacycles. A special alignment tool has been supplied for this purpose.

Use of precise one megacycle reference frequency:

1. Remove internal crystal

2. Inject external signal into J402 which may be reached from the rear of the cabinet. A minimum level of 0.5 volts rms at high impedance is required.

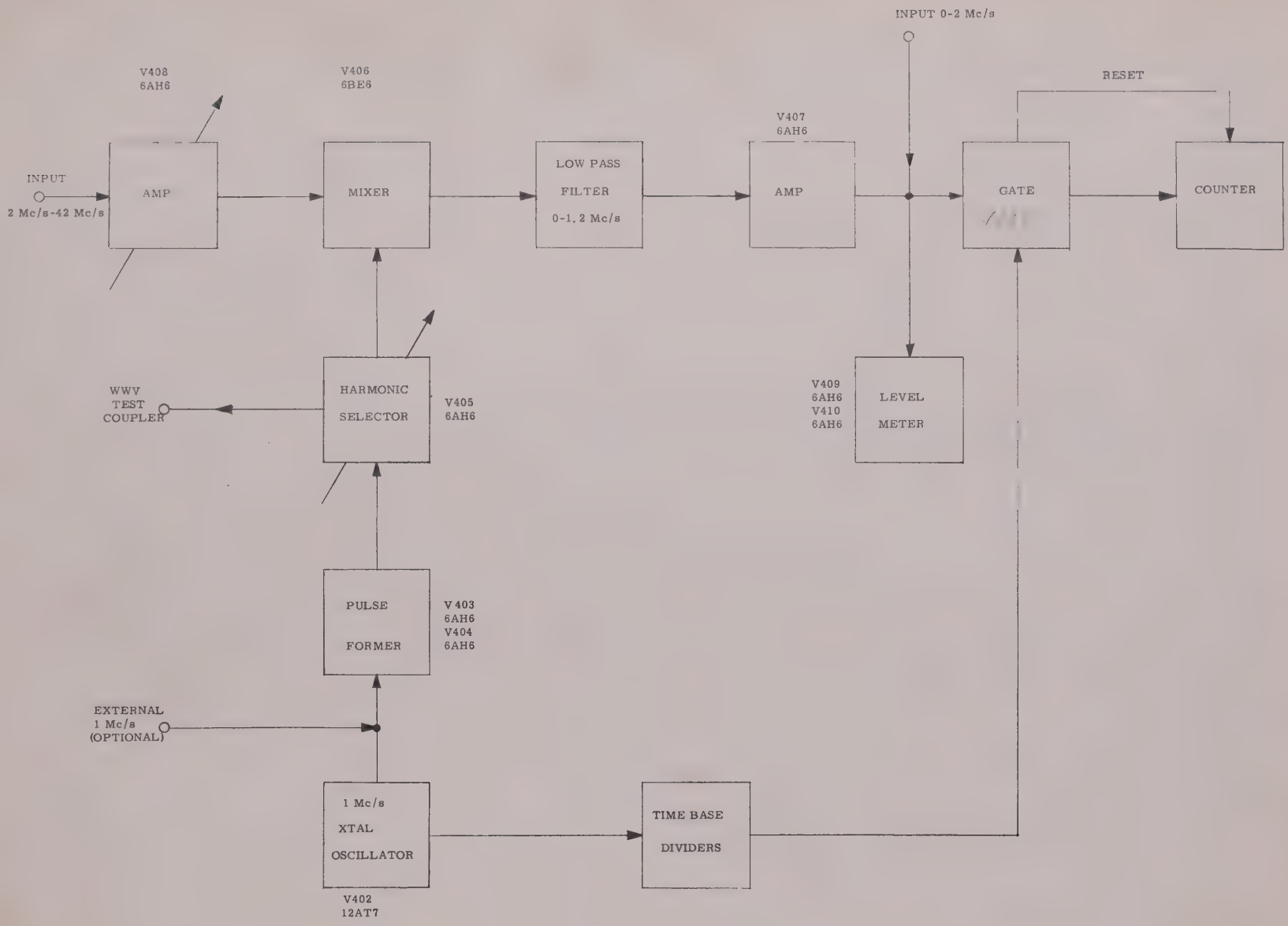


Figure 3 Functional Diagram Model 5570

Section 3
THEORY OF OPERATION

Design

Basically, the Model 5570 consists of a Heterodyne unit, Events-per-Unit-Time meter, and a Power supply. The Heterodyne unit includes an amplifier, a mixer, harmonic selector, pulse former, and a one megacycle per second crystal oscillator. The EPUT section which is similar to the Model 5558 contains an accurate time base, electronic gate, and a system of cascaded Decimal Counting Units (DCU's).

Figure 3 is a functional diagram of the complete instrument. The Gate Counter and Time Base Dividers form the Indicator unit and the remaining sections, the Heterodyne unit. A third unit supplies power for the instrument. The Indicator unit is a complete counting instrument with a maximum frequency response of 2 MC. The Heterodyne unit converts high frequencies to frequencies within the range of the Indicator unit.

The Heterodyne Unit

An unkown frequency is amplified by V408 and applied to the first control grid of mixer V406 (see Figure 4). A precise reference frequency of any integral number of megacycles between 2 and 41 may be applied to the second control grid of V406 (pin 7) as selected by the turret switch. The plate circuit of V406 consists of a three section low pass filter with a cut-off frequency of approximately 1.2 Mc. If the two frequencies injected into V406 are less than 1.2 Mc apart, a beat frequency is produced which passes through the low pass filter to reach the output amplifier V407. Further amplification of this beat frequency by V409 and V410 drives the Set Level meter (M401).

Precise reference frequencies are derived from a highly stable crystal oscillator (V402). In this circuit the amplitude of oscillation is automatically controlled by the positive feedback thermister I401 and the frequency governed by the frequency at which Y401 and C403 are in series resonance. The 1 Mc output from this oscillator is amplified by V403 and the very large amplitude applied to the grid of L404 causes L402 to ring.

The first positive going overshoot causes a large current pulse to flow in the plate circuit of V405. L403 is a low loss coil tuned by capacitors selected by the turret switch to integral frequencies between 2 and 41 Mc. A very high Q is maintained over the entire range so that the tuned circuit extracts the proper frequency component from the applied pulse. A single turn coupling loop (L405) couples a small amount of energy to V406 at the desired reference frequency (see Figure 9).

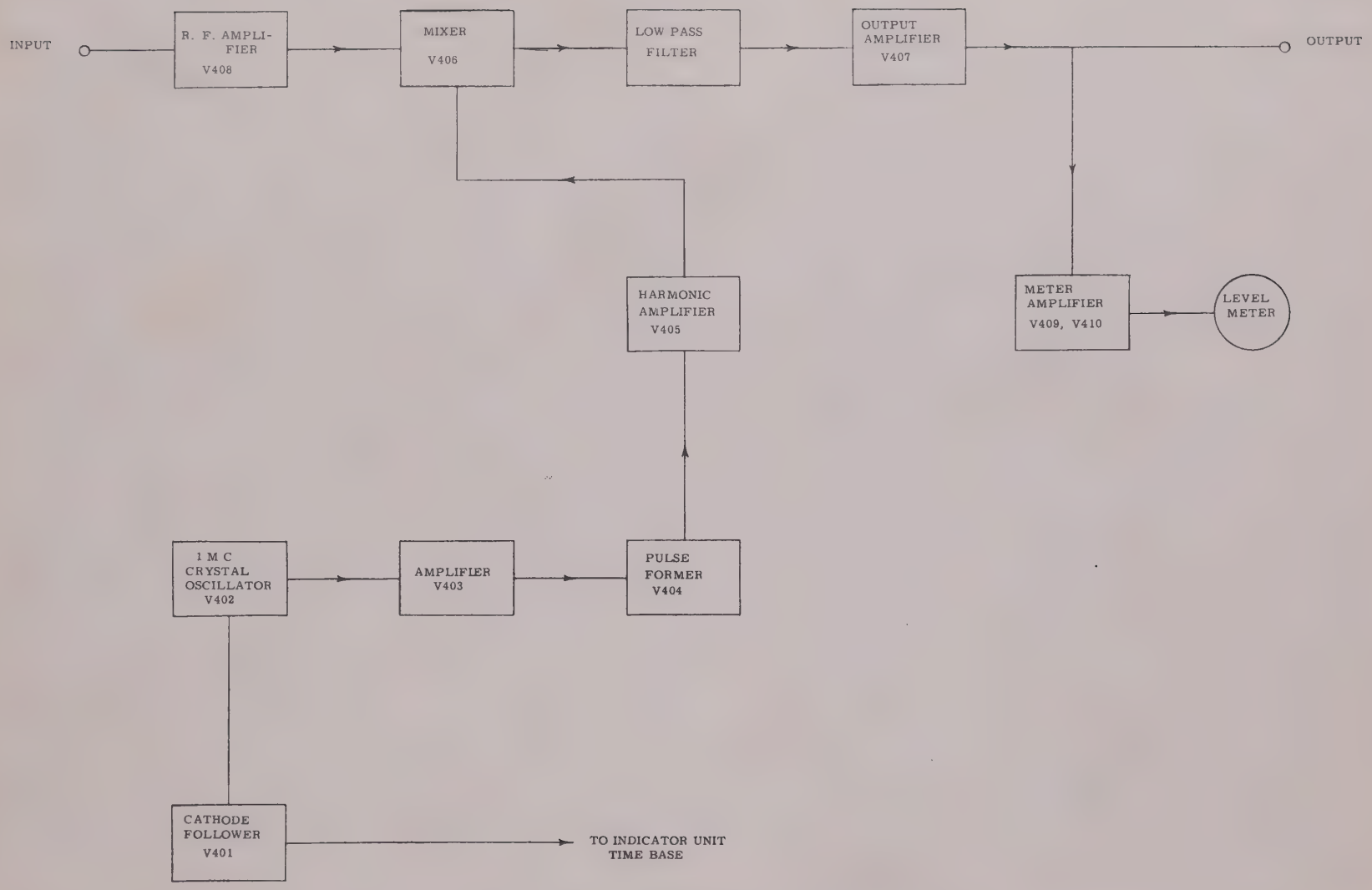


Figure 4 Functional Diagram Heterodyne Unit

Indicator Unit

The Indicator unit consists of an input circuit, an electronic gate opened and closed by a time base synchronized with a 1 Megacycle precision sine wave from the Heterodyne unit, and a series of six electronic decade counting units (see Figure 5). Input signals are amplified, shaped and conducted to an electronic gate. The gate is opened by a signal from the time base, remains open for an accurately controlled interval, and closes on a second signal from the time base. After the gate closes, the total number of events counted is displayed on the illuminated DCU panels. A switch on the front panel allows the operator to disconnect the time base from the gate and to use the instrument as an ordinary counter. The basic accuracy of this unit is essentially ± one event for any input frequency, the irreducible error of all electronic counters. ~~(see Figure 8).~~

Input attenuator. The input signal is coupled to the amplifier through an attenuator which consists of three frequency compensated voltage dividers, 10, 20 and 30 decibels attenuation, respectively. The 0 db attenuation position makes a direct capacitive coupling between the input and the amplifier. The three-tube feedback loop type input amplifier has a fixed feedback gain of about 100. Considerable gain stability is achieved with the feedback circuit. From 10 to 2,000,000 cps, the frequency response only varies 3 db.

Schmitt discriminator. The output signal of the input amplifier operates a Schmitt discriminator circuit, a circuit with two stable states. It remains in one state as long as the input signal is zero or remains below a certain amplitude, and switches to the other state when the input signal amplitude exceeds this value.

Potentiometer R121 controls the triggering level of the input grid which in turn determines the input sensitivity of the unit. R121 is normally set for maximum sensitivity. About 30 milivolts rms at the input is a typical requirement. The output from the Schmitt drives a binary circuit via V105 and CR102 and CR103. For every two cycles of the input signal, an output pulse is obtained from this stage.

L101 in the right plate circuit of V111 is paralleled with the stray capacity across it to form a ringing circuit with a resonant frequency of about 1.5 megacycles. CR104 and R188 prevent oscillation after the first half-cycle to produce a positive pulse with a period of 0.35 microseconds and an amplitude of 10 volts. This pulse applied to the signal gate tube V112 through C149, drives the first DCU (AY101).

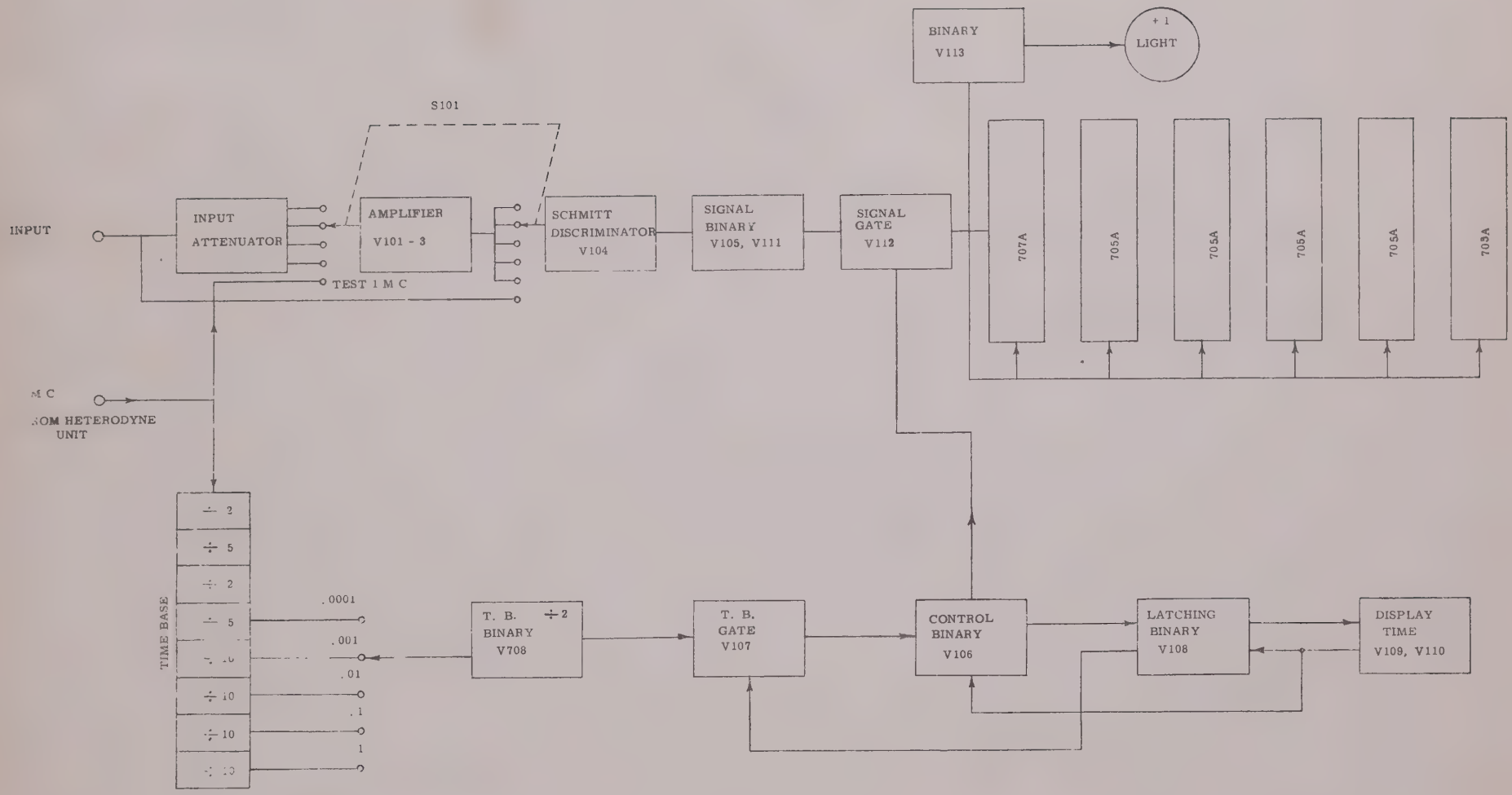


Figure 5 Functional Diagram Indicator Unit

Signal gate. V112 the signal gate, has two control grids, one obtains its signal from the input binary circuit (V111); the other, from the control binary, V106. The plate of the signal gate tube is connected directly to the cathodes of the triggering diodes in the Model 707A (See Appendix B). The second control grid of V112 (pin 7), connected to the control binary, is held at ground potential by the control binary during the counting period. During the remainder of the counting cycle, this grid is held below its cutoff voltage. The first grid of V112 (pin 1), connected to the input binary circuit (V111) is normally biased below cutoff. Positive pulses from the input binary circuit raise this grid above the cutoff point and during the counting period, initiate a current flow through V112, which drives AY101.

Time base gate and control and latching binaries. These units are interdependent, and are therefore discussed jointly. The cathodes of V107 are connected to ground through R140. Since the grids of V107 are d-c connected through R138 and R139 to their respective plates and a-c coupled to the cathodes, either half of V107 acts as a diode when its plate is at or near ground. Each plate of V106, the control binary (which is connected directly to the plate of V107), is near ground potential in the non-conducting state. The potential of the conducting plate (thus the corresponding plate and grid of V107) is considerably below ground. Rectangular waveforms from the time base are differentiated by C127 and R140, producing alternate positive and negative pulses at the cathodes of V107. Positive pulses raise the cathodes above ground so that no conduction occurs through V107; negative pulses cause one side or the other to conduct. The half of V107 conducting is connected to the plate of the non-conducting side of the control binary, V106. In this way, a negative signal from the time base causes the control binary to change to its opposite state, either starting or terminating the counting period. At the beginning of the counting period the control binary is changed from one state to the other. If the right side conducts, the left cuts off. V108, the latching binary, is designed so that when its right side conducts, the left side cuts off. The positive pulse introduced by the control binary through C120 at the start of the counting period does not alter this condition. At the end of the counting period, however, the left plate of V106 goes negative, applying a negative pulse through C120 to the right grid of V108 via the cross-over network which causes the latching binary to change to its other state. Two actions occur as a result of this change.

First, the divider R138 and R161 lowers the grid of V107 to a potential below ground which cuts off this half of V107 (the plate and grid of the other half are already below the cathode potential.) When the next pulse from the time base arrives at the cathodes of V107, the grids are carried by C120 and C133. As long as the latching binary holds the V107 grid below cathode potential, the control binary cannot be triggered from the time base and V112, the signal gate tube, is cut off, which prevents pulses from reaching the 707A DCU (AY101).

Second, the half of V110 whose grid is connected to the left plate of V108 is cut off, allowing C124 to charge up through R151 and R153. The voltage across C124 increases until the firing potential of the thyratron V109 is reached, causing it to fire, producing a positive voltage pulse across the cathode resistor, R154. This pulse resets the DCU's. It also resets the control and latching binaries through R154 connected to the left and right grids, respectively. Normally, the control binary has been reset at the end of the counting period, but the reset pulse assures proper position for the next counting cycle. Additionally, the bias from the grids of V107 and V110 is removed, permitting the former to function as a diode and the latter preventing C124 from charging up to the firing potential of thyratron V109. From this state, the circuit will respond to the next counting cycle which begins when the next pulse from the time base triggers the control binary.

The DISPLAY TIME (R153) setting determines the charging time of C124. R158, which controls the firing potential of V109, is factory adjusted for a maximum display time of about seven seconds, S108 AUTO-MAN, disconnects the common plates of V109 and V110 from their voltage supply which prevents the automatic reset from operating. The RESET pushbotton connects a positive potential to the plate of V109 and causes the DCU's and control and latching binaries to be reset similarly to the manner of the automatic reset circuit. With the UNIT TIME in COUNTER, S104, the COUNT switch, opens the cathode circuit of either half of the control binary, V106, forcing it to either of its two states. Thus, with the circuit in manual operation, the instrument can be operated as a counter.

Time Base

The time base consists of a 500 Kc blocking oscillator synchronized by a precision 1 Mc sine wave fed from the Heterodyne unit, followed by a chain of dividers (V701 to V707). The output from the last divider provides pulses at intervals of precisely 1 second. The time base output is connected to the gating circuit via the time base binary V708, a maximum sampling period of 2 seconds is thereby achieved (see Figure 7).

Operation As A Pulse Counter

For repetition rates not exceeding 2 Mc the Indicator Unit may be used as a pulse counter. So used, set up the Schmitt circuit as follows:

1. Set R121 in the extreme clockwise position so that the right side of V104 conducts.

2. Apply a positive d-c voltage of 7 volts to the input connector with the attenuator switch on DISCR.

3. Rotate R121 in a counterclockwise direction until V104 triggers and cuts the right side off.

4. Remove the d-c voltage. V104 should trigger back, the right side conducting. Failure to trigger is indicative of a faulty tube or component.

To adjust the input circuit for response to negative pulses alone, the procedure detailed above is followed except that in (1), R121 is placed in the extreme counterclockwise position; (2) a negative d-c voltage is applied; (3) R121 is rotated clockwise and the left side cut-off, and (4) the left side conducts.

Power Supply

The power supply provides 6.3 volts 60 c/s for the heating of filaments and four different direct voltages as listed.

+290 volts unregulated
+120 volts regulated
-150 volts regulated
-300 volts unregulated

Design is conventional, regulation is achieved electronically using the potential drop across a gas filled tube (OB2) for reference.

Section 4
MAINTENANCE

Before leaving the factory, this instrument was carefully aligned. Readjustment should not be necessary for a long time. Normally, the replacement of a tube or component will have no effect on the operation except in the Time Base. Properly aligned sets have been operated for many months without readjustment.

Where faulty operation is suspected, do not attempt to service the instrument without reference to the Service Chart (Table 2). Proceed according to the directions therein before taking any remedial action.

Routine Adjustments

Trigger Adjust. R187 controls the drive voltage on the first DCU (AY101). To adjust this voltage set the INPUT SELECTOR on 1 Mc and vary R187 until the extreme positions for correct counting have been determined. Repeat this adjustment using a 10 Kc external signal. The inner positions for each frequency delineate the region of proper operation over the whole frequency rante. Set R187 midway between these two points.

Schmitt Descriminator. R121, the DISC ADJ, controls the Schmitt circuit. To set this circuit for maximum sensitivity, turn UNIT TIME to CNTR, inject an external signal of any frequency between 1 Kc sec and 1 Mc/sec and alternately adjust R121 and lower the input level until the maximum sensitivity is reached (about 30 millivolts rms).

Time Base. To properly adjust the time base, adhere strictly to the following procedure:

1. Check level of 1 Mc input at P102.

2. Connect wide-band scope to test point Eo and check waveform A. Pay particular attention to the regularity of the 2μs pulses (waveform B is not acceptable).

3. If the waveform at Eo is incorrect, disconnect the 1 Mc input from J102 and adjust DIV 1 and DIV 2 for the correct waveform.

Does not count
A + C waves
Reg control

Ted Patterson
Line 429

4. Replace 1 Mc input and readjust DIV 1 only to regain correct picture.

5. Move scope to E1 and adjust DIV 3 for division by 5 (waveform C).

6. Turn UNIT TIME to .0002 and cross check previous adjustments by observing count of 100 ±1.

7. Turn UNIT TIME to .002 and adjust DIV 4 for a count of 1000 ±1.

8. Turn UNIT TIME to .02, adjust DIV 5 for a count of 10,000 ±1.

9. Turn UNIT TIME to .2, adjust DIV 6 for a count of 100,000 ±1.

10. Turn UNIT TIME to 2, adjust DIV 7 for a count of 1,000,000 ±1.

11. Return UNIT TIME to .0002 and readjust DIV 1, DIV 2, DIV 3 for center of respective ranges which produce counts of 100 ±1.

12. Turn UNIT TIME to .002 and set DIV 4 to center of range (count 1000 ±1).

13. Turn UNIT TIME to .02, set DIV 5 to center (count 10,000 ±1).

14. Turn UNIT TIME to .2, set DIV 6 to center (100,000 ±1).

15. Turn UNIT TIME to 2, set DIV 7 to center (1,000,000 ±1).

16. Repeat 11 to 15 until all dividers have range of at least ±20°.

17. Vary line voltage between 105 and 130 volts. The count should hold 1,000,000 ±1 (UNIT TIME at 2).

Table 2
SERVICE CHART

Follow procedure in strict sequence:

	TEST	OBSERVED RESULT	ROUTE
T1	Input selector to "TEST X 1 Mc", UNIT TIME to 2	Count 1,000,000 ±1	Proceed to T12
		Count not 1,000,000 ±1	Proceed to T2
T2	UNIT TIME to .2	Count 100,000 ±1	Return to T1. Adjust DIV 7 or replace DCU AY106
		Count not 100,000 ±1	Proceed to T3
T3	UNIT TIME to .02	Count 10,000 ±1	Return to T2. Adjust DIV or replace DCU AY104
		Count not 10,000 ±1	Proceed to T4
T4	UNIT TIME to .002	Count 1,000 ±1	Return to T3. Adjust DIV 5 or replace DCU AY104
		Count not 1,000 ±1	Proceed to T5
T5	UNIT TIME to .0002	Count 100 ±1	Return to T4. Adjust DIV 4 or replace DCU AY103
		Count not 100 ±1	Proceed to T6
T6	Check waveform C (Figure 6) at test point E1	Correct	Return to T5. Adjust TRIGGER ADJ. RESET RANGE ADJ. or replace DCU AY102 or AY101
		Waveform correct but division ration not 5 or unsteady	Proceed to T7
		Wave shape incorrect	Proceed to T11

	TEST	OBSERVED RESULT	ROUTE
T7	Check waveform A (Figure 6)	Correct	Return to T6. Adjust DIV 3
		Incorrect or unsteady	Proceed to T8
T8	Check level of 1 Mc INPUT (P102)	More than 3 volts peak to peak or 1 volt rms.	Proceed to T9
		Less than 3 volts peak to peak or 1 volt rms.	Proceed to T10
T9	Re-align time Base		Return to T1
T10	Replace tube V401		Return to T1
T11	Check voltages and waveforms of V702		Return to T1
T12	UNIT TIME to 2 Swing line voltage slowly between 105 and 130 volts	Count always 1,000,000 ±1	Proceed to T13
		Count not always 1,000,000 ±1	Return to T9
T13	INPUT SELECTOR to 0 db. Inject sine wave at 10 Kc/s.	Correct count	Proceed to T14
		Incorrect count	Reset TRIGGER ADJ.
T14	Reduce 10 Kc/s level to minimum for correct count	Level more than 50 millivolts rms	Proceed to T15
		Level less than 50 millivolts rms	Proceed to T16
T15	Reset "DISC ADJ."		Proceed to T16
T16	Check waveform and level of signal being injected to input of INDICATOR UNIT under condition where failure is obtained.		
T17	See Troubleshooting		

Troubleshooting

Schematics, waveforms and several maintenance charts have been included in this section as servicing aids. Proper troubleshooting requires a good VTVM and a high quality oscilloscope. In the event of failure, follow the procedure described in Table 2. Table 3 lists several of the more common troubles. This list is by no means exhaustive, but should serve as a guide. As in any electronic device, tubes are the most frequent cause of failure.

Table 3
TROUBLESHOOTING CHART

(A) Indicator unit fed directly from external signal (Frequencies below 2 Mc).

Symptom	
Correct count on Test, incorrect on external signal.	Input level too high or too low - check by adjusting INPUT SELECTOR.
Correct count at high frequency but incorrect at low frequency.	707A. Try resetting TRIGGER ADJ.
Reads 1249 or 125 in TEST position.	707A. Try resetting TRIGGER ADJ.
Reads 2000 or 1999 in TEST position.	707A. Try resetting TRIGGER ADJ. Check binary V111.

(B) All sections of instrument in use. (Frequencies above 2 Mc).

Meter deflection independent of position of Frequency Selector.	Input cable picking up signal below 2 Mc. or Signal has low frequency modulation and GAIN is too high.
Instrument apparently normal in behavior but count is low or erratic.	Signal has amplitude modulation in excess of 30% Check beat frequency waveform at OUTPUT socket of Heterodyne unit. or Indicator Unit insensitive Check "DISC ADJ."

Meter continuously deflected without input signal (instrument near source of very strong signal).	Failure of R.F. filter in power supply unit or Front panel of Heterodyne unit not properly fastened
Instrument apparently normal but count is high and erratic when measuring low frequency beats.	Meter circuit insensitive resulting in overdrive of counter. Reset R446 as follows: inject 200 Kc signal directly into Heterodyne unit and adjust level until VTVM or oscilloscope connected to OUTPUT socket shows 90mV rms. Adjust R446 until meter reads at lower red/green boundary.
First two columns of lights in indicator section fail to light correctly.	Rear set of contacts behind turret switch in Heterodyne unit require adjustment. Right hand side of chassis may be removed to allow inspection.

All voltages shown on the circuit diagrams were measured relative to chassis with a VTVM with the instrument controls set as follows:

DISPLAY TIME	anti-clockwise
AUTO/MANUAL	AUTO
UNIT TIME	.0002
COUNT	on
INPUT SELECTOR	TEST 1 Mc.

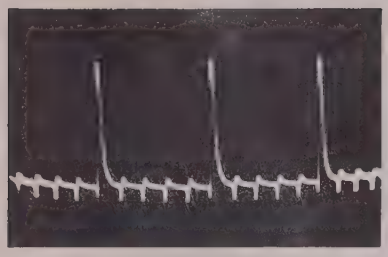
Table 4
VOLTAGES

Tube	Pin No.	Voltage	Remarks
V708	1, 6	230	V708 removed
V708	2, 7	59	V708 removed
V111	1, 9	97	V111 removed
V111	2, 7	52	V111 removed
V113	1, 6	210	V113 removed
V113	2, 7	68	V113 removed
V106	1	8	V106, V108 removed
V106	2, 7	-105	V106, V108 removed
V106	9	6.5	V106, V108 removed
V108	1	9	V106, V108 removed

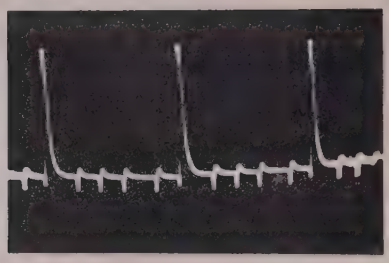
The potentials listed above were measured under the same conditions except as indicated.

NOTE

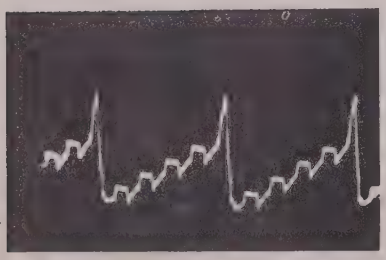
The following photographs were taken from a Tektronix 514D oscilloscope with a 4x5 Grover View camera at f4.5 at $\frac{1}{2}$ second.



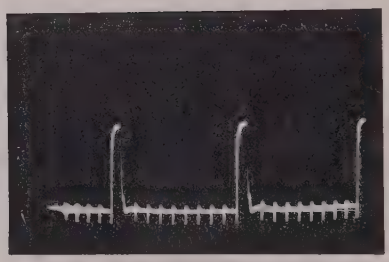
A. Test point E_o (correct waveform), 26 volts peak-to-peak, 10 μsecs. between positive peaks.



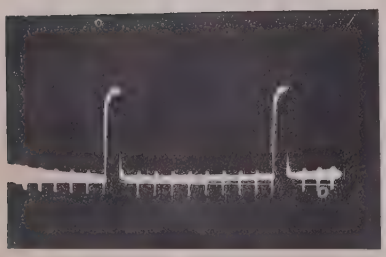
B. Test point E_o (incorrect waveform).



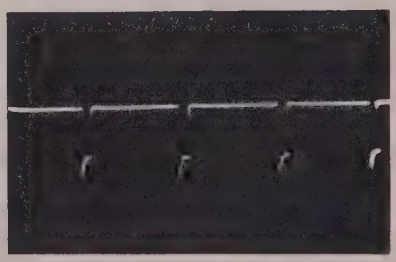
C. Test point E_1, 17 volts peak-to-peak, 100 μsecs. between positive peaks.



D. Test point E_2, 80 volts peak-to-peak, 1000 μsecs. between positive peaks.

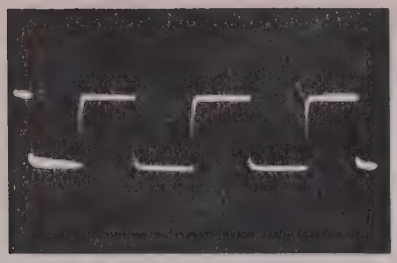


E. Test point E_3, 80 volts peak-to-peak, 10 milliseconds between positive peaks.

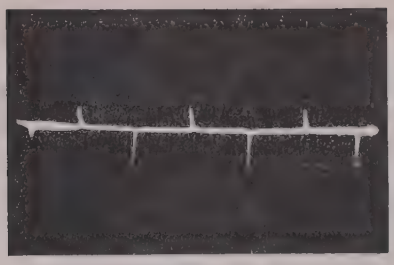


F. Input to Time Base output binary (pin 6 V706). Unit Time switch at .002, 83 volts peak-to-peak.

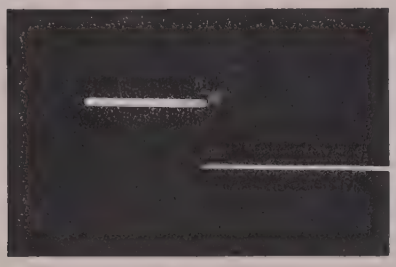
Figure 6 Typical Waveshapes



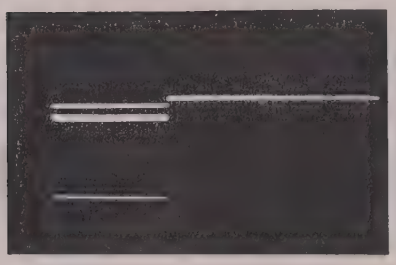
G. Time Base output to gate circuits (junction R791 and C127). Unit Time switch at .002, 120 volts peak-to-peak.



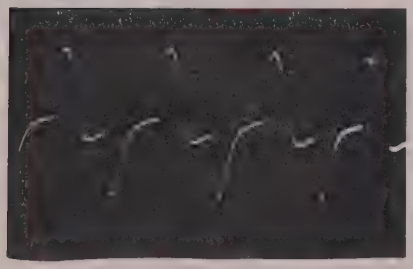
H. Differentiated input to gate circuits (pin 3, 8 of V107). Unit Time switch at .002, 98 volts peak-to-peak.



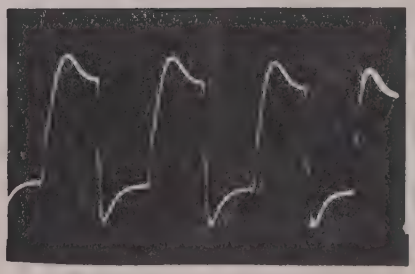
J. Gate control waveform (pin 7, V112). Unit Time switch at .002, 28 volts peak-to-peak.



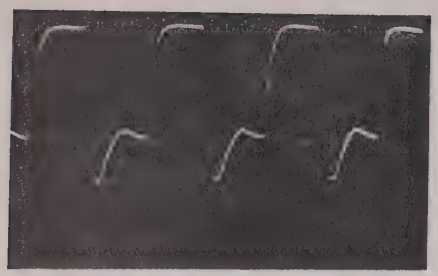
K. Gated output (pin 5, V112). Unit Time switch at .002. Input Selector at TEST 1 MC., 50 volts peak-to-peak.



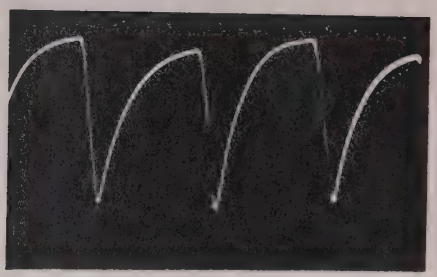
L. Signal input to gate (pin 1, V112). Input Selector in TEST 1 MC. position, 24 volts peak-to-peak.



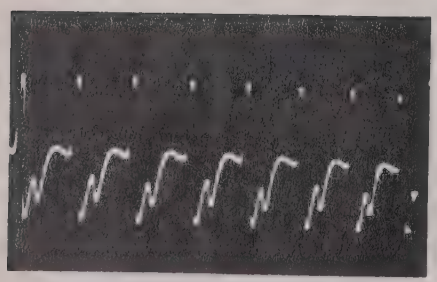
M. Output from signal binary (pin 9) V111. Input Selector in TEST 1 MC. position, 60 volts peak-to-peak.



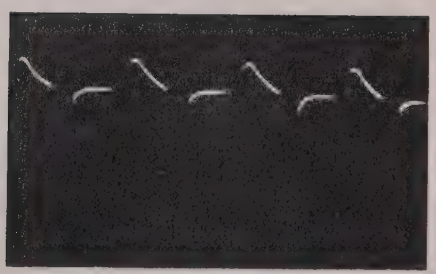
N. Output from signal binary (pin 1, V111). Input Selector in TEST 1 MC. position, 60 volts peak-to-peak.



O. Input to decimal counter units (pin 5, V112), Unit Time switch in CNTR position, Input Selector in TEST 1 MC. position, 50 volts peak-to-peak.



P. Output from Schmitt discriminator (pin 1, V105), Input Selector in TEST 1 MC. position, 30 volts peak-to-peak.



Q. Input to signal binary (pin 5, V105), Input Selector in TEST 1 MC. position, 30 volts peak-to-peak.

Section 5
PARTS LIST

Non-Standard Components

Detail No.	Stock No.	Item	Description	Manufacturer & No.
		Heterodyne unit		
L406,				
L408	3-3198	Inductor	1 MH W/Shield	Carad
L402	3-3079	Inductor	12 Microhenries	Carad
L403-L405		Inductor	Special	BSC
P401	11-3259	Plug		Cannon AN 3108B-20-27P
P402	11-3258	Plug		Cannon AN 3108B-18-1P
P403	11-3239	Plug	2 M, W/1119 PH Contacts	Elco "Varicon"
	11-2081	Plug		IPC UG 260/U
Y401	13-3073	Crystal	Series resonant at 1 Mc with 5$\mu\mu$f Series capacitance	Bliley BH8 Oven Type TC92
M401	15-3099	Meter	0-1 MA Special Scale	Scale Weston Mod. 506 W/D149625
J401-J405	17-0849	Receptacle		IPC 2700
J406	17-3238	Receptacle	2(F), W/2 #1101 Brackets, Black bakelite W/Hardware	Elco, "Varicon"
	17-2798	Receptacle	AN 3064-10	
I401	21-3202	Lamp	120 V, 3 Watts	GE 3-S-6

Detail No.	Stock No.	Item	Description	Manufacturer & No.
		Indicator Unit		
L101	3-3183	Choke	250 Micro-H,8 Ohm, 125 MA	Carad
T101	6-2614	Transformer	Filament	Triad #9400
T701	6-3101	Transformer		Triad X-20284
T702	6-3271	Transformer	Miniature Pulse (Blue)	PCA 101-2
CR101-CR104	8-0668	Diode	Crystal Diode	1N34A
P101	11-2703	Plug Connector	14 Conductor	AN 3106V-28-2P
S101	12-2633	Switch	Special 3 Pole, 6 Pos. Rotary	Oak Mfg. Co.
S102	12-3201	Switch	Special 3 Pole, 6 Pos. Rotary	Oak Mfg. Co.
S103	12-1641	Switch	SPDT Toggle	CH 8282K13
S104		Switch	Same as S103	
S105	12-0879	Switch	Micro-switch	BZ-2RQ1
J101	17-0849	Connector	IPC Input Connector	LV-2700 290/U
J102		Connector	Same as J101	
J103	17-2713	Receptacle	6 Pin Socket	AN 3102A-18-12S
J104	17-1665	Receptacle	10 Pin Socket	Cannon AN3102A-18-S-1S
J105	17-2603	Receptacle		Cannon AN3102A-20-27S
	17-2798	Connector	Box Type	Cannon AN3064-10

Section 5
PARTS LIST

Non-Standard Components

Detail No.	Stock No.	Item	Description	Manufacturer & No.
		Heterodyne unit		
L406, L408	3-3198	Inductor	1 MH W/Shield	Carad
L402	3-3079	Inductor	12 Microhenries	Carad
L403-L405		Inductor	Special	BSC
P401	11-3259	Plug		Cannon AN 3108B-20-27P
P402	11-3258	Plug		Cannon AN 3108B-18-1P
P403	11-3239	Plug	2 M, W/1119 PH Contacts	Elco "Varicon"
	11-2081	Plug		IPC UG 260/U
Y401	13-3073	Crystal	Series resonant at 1 Mc with 5$\mu\mu$f Series capacitance	Bliley BH8 Oven Type TC92
M401	15-3099	Meter	0-1 MA Special Scale	Scale Weston Mod. 506 W/D149625
J401-J405	17-0849	Receptacle		IPC 2700
J406	17-3238	Receptacle	2(F), W/2 #1101 Brackets, Black bakelite W/Hardware	Elco, "Varicon"
	17-2798	Receptacle	AN 3064-10	
I401	21-3202	Lamp	120 V, 3 Watts	GE 3-S-6

Detail No.	Stock No.	Item	Description	Manufacturer & No.
		Indicator Unit		
L101	3-3183	Choke	250 Micro-H, 8 Ohm, 125 MA	Carad
T101	6-2614	Transformer	Filament	Triad #9400
T701	6-3101	Transformer		Triad X-20284
T702	6-3271	Transformer	Miniature Pulse (Blue)	PCA 101-2
CR101-CR104	8-0668	Diode	Crystal Diode	1N34A
P101	11-2703	Plug Connector	14 Conductor	AN 3106V-28-2P
S101	12-2633	Switch	Special 3 Pole, 6 Pos. Rotary	Oak Mfg. Co.
S102	12-3201	Switch	Special 3 Pole, 6 Pos. Rotary	Oak Mfg. Co.
S103	12-1641	Switch	SPDT Toggle	CH 8282K13
S104		Switch	Same as S103	
S105	12-0879	Switch	Micro-switch	BZ-2RQ1
J101	17-0849	Connector	IPC Input Connector	LV-2700 290/U
J102		Connector	Same as J101	
J103	17-2713	Receptacle	6 Pin Socket	AN 3102A-18-12S
J104	17-1665	Receptacle	10 Pin Socket	Cannon AN3102A-18-S-1S
J105	17-2603	Receptacle		Cannon AN3102A-20-27S
	17-2798	Connector	Box Type	Cannon AN3064-10

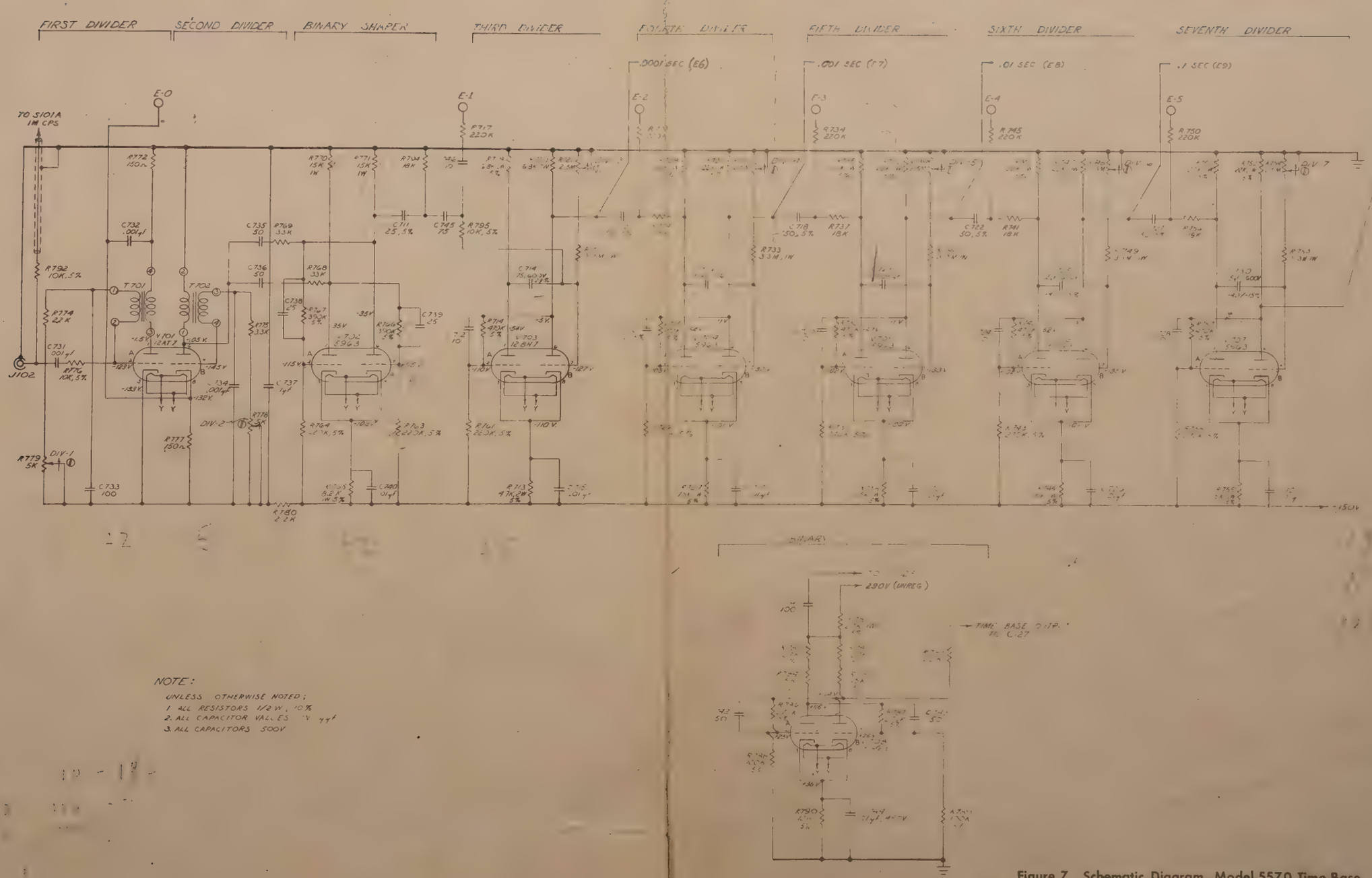
Detail No.	Stock No.	Item	Description	Manufacturer & No.
J106	17-1748A	Receptacle		Cinch 12844
	20-0735A	Feed Thru		Unesco 1433
I101	21-1679	Neon Lamp	1/25 W, 105-125V	GE NE 51
I102-I116	21-0426	" "		NE 2
		Power Supply		
L301	3-2615	Choke	Hermetically sealed Filter 10H, 300MA, 85 Ohm	Triad Type #HS-319 14261
L302	3-2616	"	Filter 15H, 120MA, 185 Ohm	Triad Type #HS-307 14262
L303	3-3170	"	5.5 Micro-H	Carad Corp.
L304			Same as L303	
T301	6-2612	Power Transformer		Triad #7188
T302	6-2083	Filament Trans.		Triad 9518
F301	7-2601	Fuse	8 Amp. 125V	Littelfuse 312008
F302		"	Same as F301	
F303	7-1099	"	½ Amp. 250V	Littelfuse #312500
F304		"	Same as F303	
CR310-CR302	8-1699A	Selenium Rectif.		Selectron 6 M1
S301	12-1642	Switch	DPST Toggle	CH 8370K8
J301	17-3185	Connector		Hubbel 7486
J302	17-2642	"	14 Hole, Box mounting receptacle	Cannon AN 3102A-28-2S

Detail No.	Stock No.	Item	Description	Manufacturer & No.
I301	21-1677	Lamp, Pilot	15A, 6-8V	GE #47
I302		Lamp, Pilot	15A, 6-8V	

Tube Complement

	Type	No. Required per Unit
		Heterodyne unit
8*	6AH6	8 (V401,403, 404, 405, 407, 408, 409, 410)
1*	12AT7	1 (V402)
1*	6BE6	1 (V406)
		Indicator unit
3*	6AU6	3 (V101, 102, 105)
1*	5964	1 (V103)
3*	5687	3 (V104, 106, 111)
10*	5963	10 (V107, 108, 110, 113, 702, 704, 705, 706, 707, 708)
1*	2D21	1 (V109)
1*	6AS6	1 (V112)
1*	12AT7	1 (V701)
1*	12BH7	1 (V703)
		Power supply
2*	5U4G	2 (V301, 302)
2*	6AS7 or 6080	2 (V303, 304)
2*	6AU6	2 (V305, 306)
2*	OB2	2 (V307, 308)

Asterisk indicates recommended spare part. Number preceding indicates quantity.



NOTE:

UNLESS OTHERWISE NOTED;
1. ALL RESISTORS 1/2 W, 10%
2. ALL CAPACITOR VALUES IN μμf
3. ALL CAPACITORS 500V

Figure 7 Schematic Diagram, Model 5570 Time Base

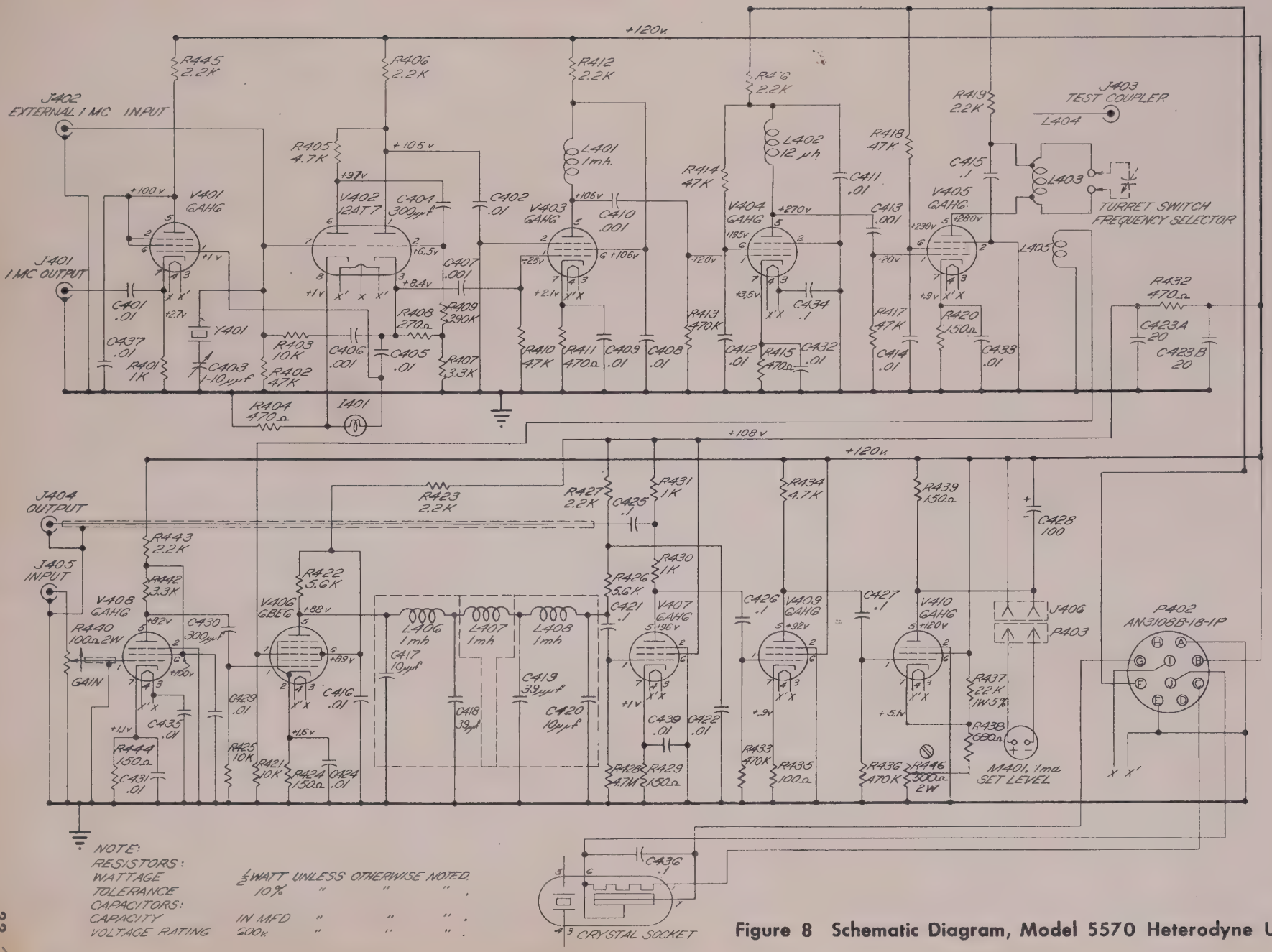


Figure 8 Schematic Diagram, Model 5570 Heterodyne Unit

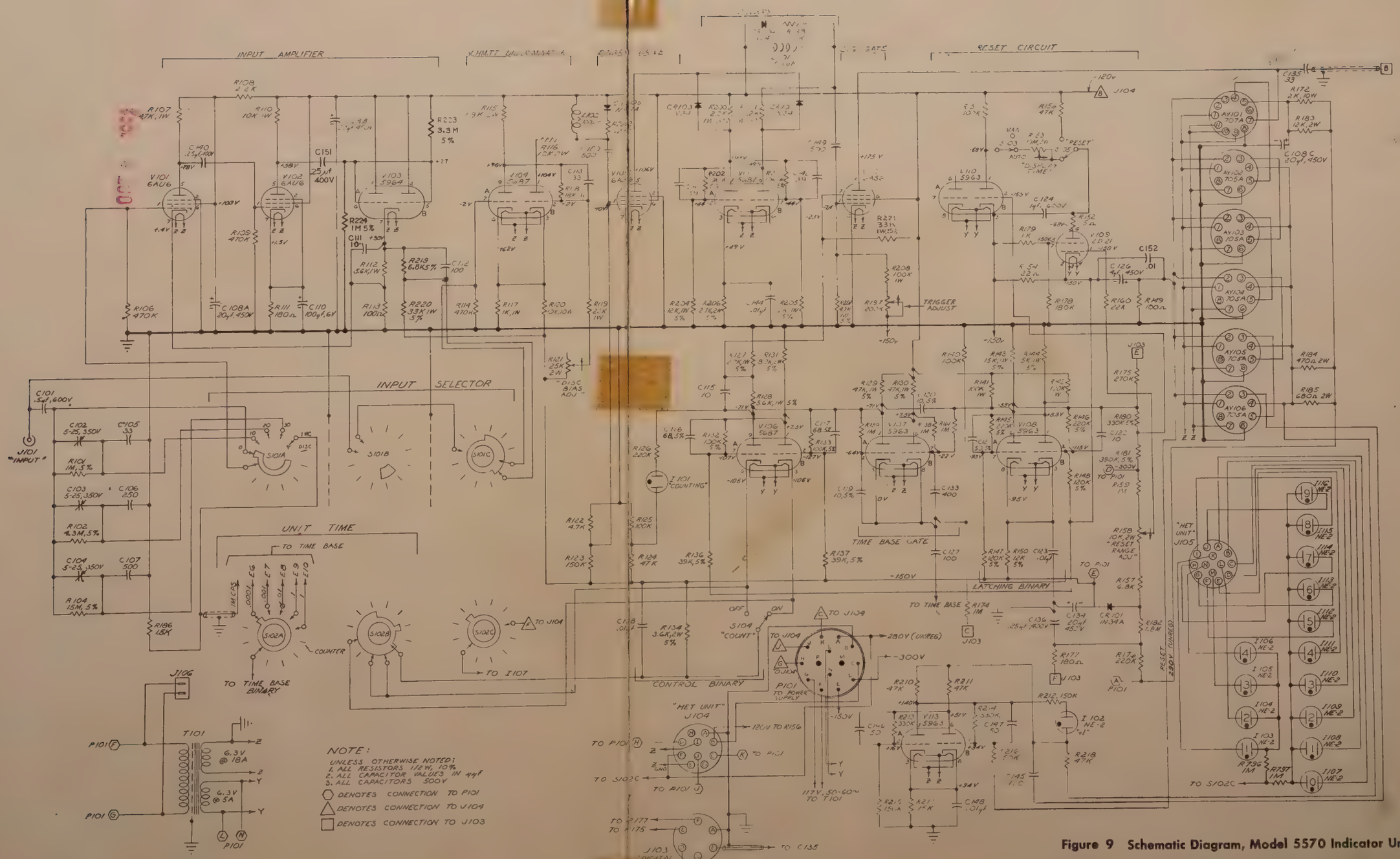
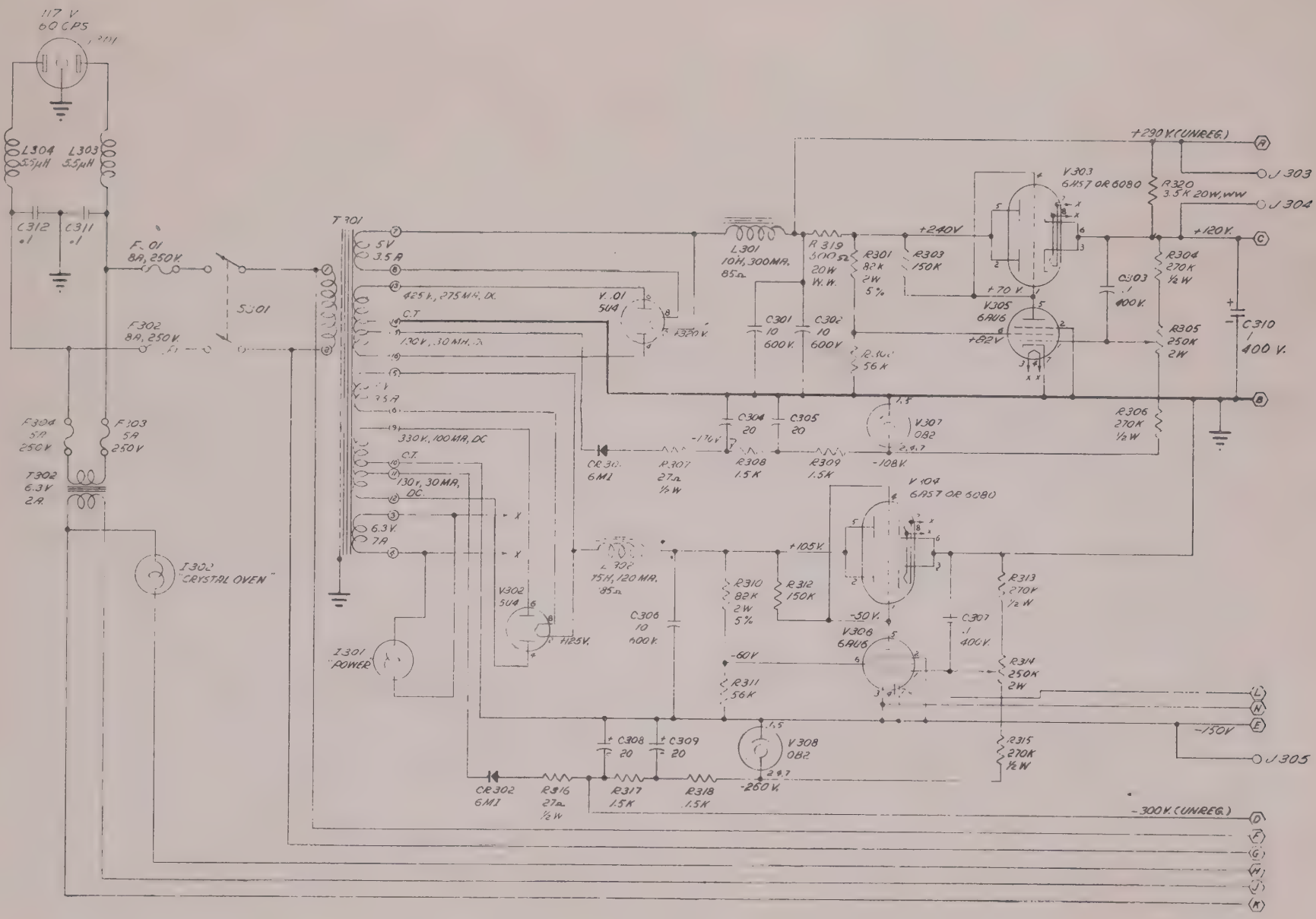


Figure 9 Schematic Diagram, Model 5570 Indicator Unit



NOTES:
UNLESS OTHERWISE NOTED;
1-ALL RESISTORS 1 W ± 10%.
2-ALL CAPACITORS 450 V.
3-ALL CAPACITORS VALUES ARE IN mfd's.
⬡ PINS IN INTER-CHASSIS CONNECTOR, J302

Figure 10 Schematic Diagram, Model 5570 Power Supply

INSTRUCTION
MANUAL

Lot 27 and up

Appendix A

Model 705A
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
1 December 1953

WARRANTY

Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.

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Berkeley division
BECKMAN INSTRUMENTS, INC

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Section 2	Operation Installation Operation	2
Section 3	Theory of Operation Basic Design Circuit Analysis	3
Section 4	Maintenance Troubleshooting Diagrams and Tables	4

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Figure 4	Typical Waveshapes, Model 705A	10
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Figure 1 Model 705A Decimal Counting Unit

Section 1
INTRODUCTION

The Model 705A Decimal Counting Unit (DCU) is a direct reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of units can be connected in cascade (the output of one unit driving the next) to form a counter whose total capacity depends only on the number of DCU's. Thus, five units will count to 99,999 and reset to 00,000 on the 100,000th pulse.

Specifications

Count Indication	Direct Reading Decimal presentation
Power Requirements	Heater: 6.3 v. at 1.2 amps Plates: 300 v. at 15 ma.
Input Requirements, recommended	Negative pulse 100 volts peak amplitude
Rise Time	Less than 1 μsecond
Duration	At least 2 μseconds
Cutput Characteristics	Designed to drive a Model 700A, 705A, or 707A
Resolution of Paired Pulses	5 μseconds
Reset to Zero	Instantaneous through opening of grid return
Maximum Counting Rate	100,000 cps
Construction	Plug-in unit octal socket
Dimensions	1-3/8" x $5\frac{1}{2}$" x $5\frac{1}{2}$"
Weight	1 lb.
Tubes	4 each 5963

Section 2
OPERATION

Installation

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Operation

Power requirements:

Plates: 250 to 350 volts (nominal 300 volts at 15 ma.)
Filaments: 6.3 volts at 1.2 amperes.

Input requirements:

If the Model 705A is powered by an unregulated supply, the drive amplitude should vary with the supply voltage. A negative transient is required to drive the unit, either a square wave or a rectangular pulse at least 2 microseconds wide. The pulse amplitude depends on the rise time. For a rise time of 0.5 microseconds (measured between ten and ninety percent values), the pulse amplitude should be between 75 and 135 volts; for a 2 microsecond rise time, an amplitude of 120 to 165 volts should be used. Rise times of 1 microsecond or less, pulse amplitudes of 100 volts, and a 300 volt supply offer optimum performance. The input load presented by either unit during triggering is equivalent to 100 $\mu\mu$f in series with 15,000 ohms.

Output requirements:

The output is a rectangular waveform presented at the output terminal as a **change** in d-c voltage (see Figure 4). Between "0" and "6", the output is 55 volts; "6" and "7", 125 volts; and "8" and "9", 135 volts. The step between "7" and "8" is caused by an interpolation network.

The load imposed on either unit must not be more than 300 K to ground or 6K in series 100 $\mu\mu$f.

Section 3
THEORY OF OPERATION

Basic Design

The basic circuit of the Model 705A is a modification of the Eccles-Jordan trigger circuit with two stable states, referred to as a binary. It is a two-stage amplifier with the output of the second stage connected to the input of the first, as shown in Figure 2.

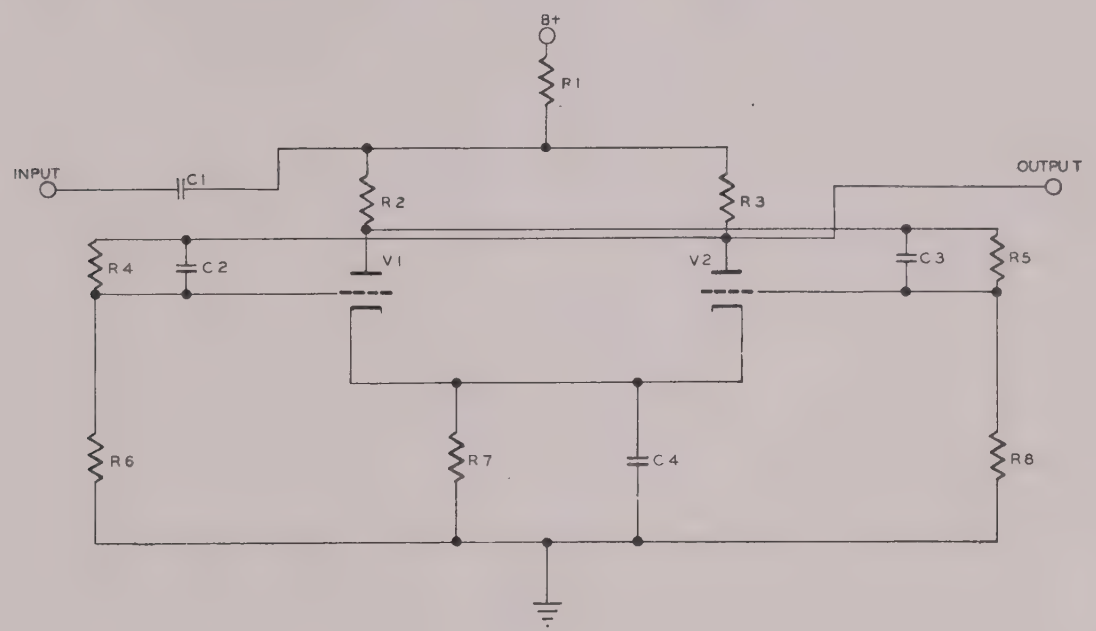


Figure 2 Basic Circuit, Model 705A

With no input, the loop gain is less than one, and the circuit is in one of its two stable states, i.e., either V2 conducting and V1 cut off, or vice-versa. The circuit is triggered from one state to the other by making the loop gain greater than one. The binary is coupled to a single trigger source through C1 and R1 in such a way that the effect of the trigger is different on the two stages, depending on which stage is conducting. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1.

This drop in voltage is transmitted through the cross-over network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. When the input pulse is of sufficient amplitude, the loop gain becomes greater than one, and the binary is triggered to its other stable state, V1 conducting the V2 cut off. The next input pulse reverses the process and causes the binary to return to its original state. Thus, the binary completes a cycle for every two input triggers, and is a scale of two. By a cascade arrangement of binaries, a counter having a scale of any power of two can be obtained.

Circuit Analysis

Four binaries are connected in cascade forming a scale of 16, which is permuted to a scale of 10 by two resistor-capacitor "feedback" networks (see Figure 3).

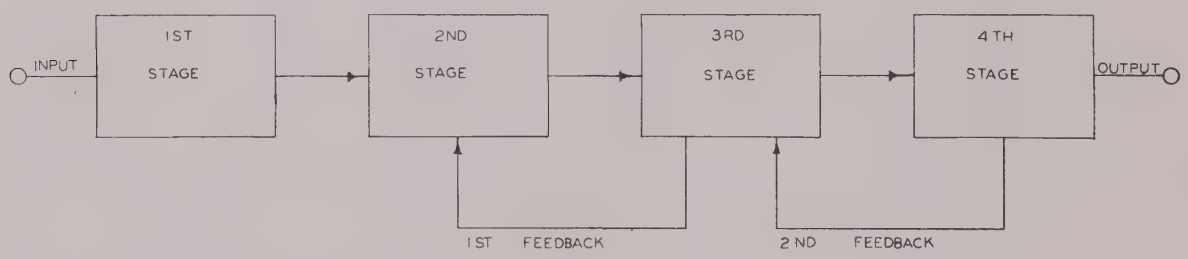


Figure 3
Functional Diagram, Model 705A

The circuit operates as a conventional binary counter up to the count of four. On the count of four the third stage is triggered, sending a pulse through the first feedback network, thereby triggering the second stage. Since it requires two inputs to trigger the second stage, this is the equivalent of adding two input pulses and the unit now corresponds to a

binary count of six. On the count of six (which is the equivalent of eight in a binary counter) the fourth stage is triggered, sending a pulse through the second "feedback" network and triggering the third stage. This is the same result as if four additional input pulses had been applied and the unit has a binary count of twelve stored in it. The unit again operates as a binary scaler for the remaining four pulses required to reset it to zero. Therefore, by adding the equivalent of six input pulses, the scale-of-16 has been permuted into a scale-of-10.

Section 4
MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit of in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Diagrams and Tables

Typical waveforms are shown in Figure 4. By comparing these with the waveforms from a defective unit, the faulty stage can be quickly detected. Table 2 lists the voltages and resistances between tube socket connections and ground so that, in conjunction with the schematics and parts location diagrams, all information necessary to maintain the equipment in proper working order is available. It should be remembered that the values given are nominal, and considerable variations may be encountered owing to various line voltage conditions and component tolerances.

Circuit drawings and parts location diagrams will be found at the rear of the manual. The voltages shown were obtained with a vacuum tube voltmeter, a supply voltage of 300 volts, and measured between ground and the point indicated. The unit must be reset to zero to obtain the values shown.

Table 1
COMMON TROUBLES*

SYMPTOM	CAUSE
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude. (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Stray output signal. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.
Unit Counts in Wrong Sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Unit skips every other number.	(a) First stage defective. (b) Input circuit supplies double pulses.
2. Two stable states per cycle.	(a) Second stage defective (count can be 01 or 45). (b) Loss of drive to second stage (01).
3. Four stable states per cycle.	(a) Third stage defective (count can be 0123 or 6789). (b) Loss of drive to third stage (0123).

4. Six stable states per cycle.	(a) Cutput excessively loaded (count can be 012345-012345). (b) Last stage inoperative (count can be 01234501 etc. or $67^{89}_{23}89$. The count $^{8}_{2}$ indicates both "8" and "2" lamps are on. (c) Loss of drive to fourth stage (count can be 012345).
5. Eight stable states per cycle or any failure where two successive numbers are skipped .	(a) Second or third stage failure
6. Ten stable states per cycle, but the lighting sequence is incorrect.	(a) Where the "0" neon lamp lights instead of the "4", the trouble is with either the "0" or "4" lamp, and in the majority of cases it is "4". This can happen on any count; zero and four were used as examples. It is also possible that more than one lamp may light in place of or with the one that fails.
7. Twelve stable states per cycle.	(a) When lighting sequence is 01 0 012345456789-0, etc. (The count 4 indicates both "0" and "4" lamps are on.) First feedback failure. Second or third stage losing emission. (b) When the lighting sequence is 23 012345678989-0, etc. Second feedback failure. Third or fourth stage losing emission.

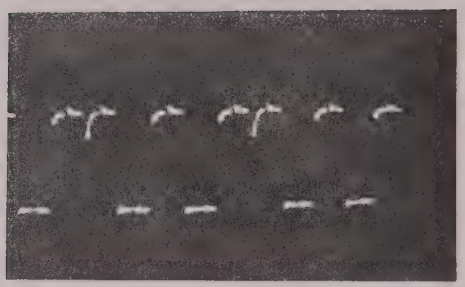
* Reset Unit before troubleshooting.

Table 2

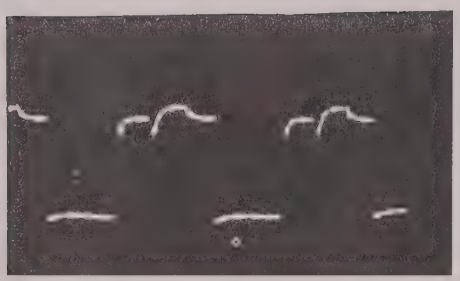
MODEL 705A - VOLTAGES & RESISTANCES

Tube	Pin No.	D. C. Voltage to Ground	Resistance to Ground (in ohms)
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K -
	7	37	85K - 240K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

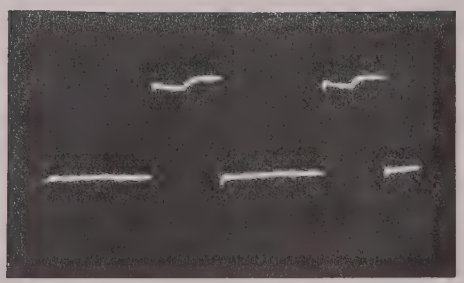
A. First Stage, Pin 6, V101, UVL + 168, LVL + 58, frequency 20Kc.



B. Second Stage, Pin 6, V102, UVL + 140, LVL + 55, frequency 20 Kc.



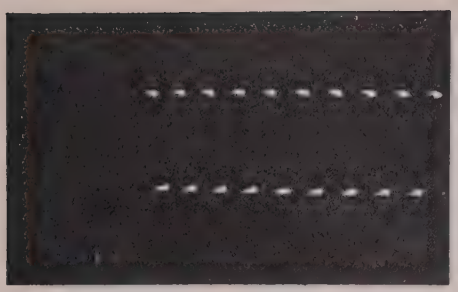
C. Third Stage, Pin 6, V103, UVL + 140, LVL + 55, frequency 20 Kc.



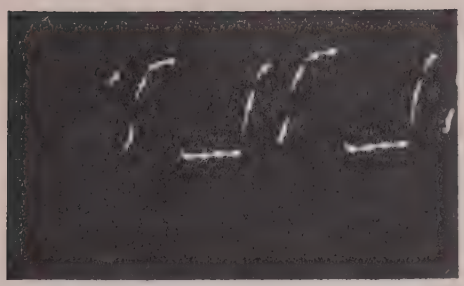
D. Fourth Stage, Pin 6, V104, UVL + 140, LVL + 55, frequency 20Kc.

Note: UVL = upper voltage level
LVL = lower voltage level
All waveforms are blanked.

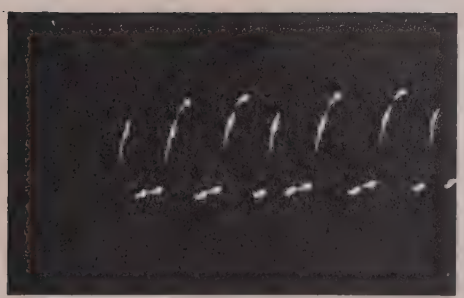
Figure 4 Typical Waveshapes



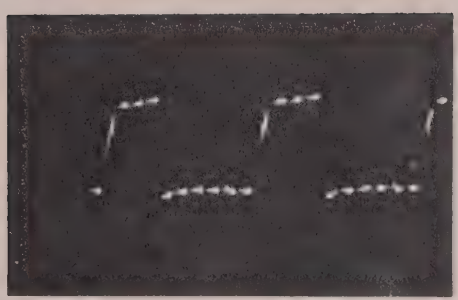
E. First Stage, Pin 6, V101, UVL + 168, LVL + 58, frequency 100Kc.



F. Second Stage, Pin 6, V102, UVL 140, LVL + 55, frequency 100Kc.



G. Third Stage, Pin 6, V103, UVL + 140, LVL + 55, frequency 100Kc.



H. Fourth Stage, Pin 6, V104, UVL + 140, LVL + 55, frequency 100 Kc.

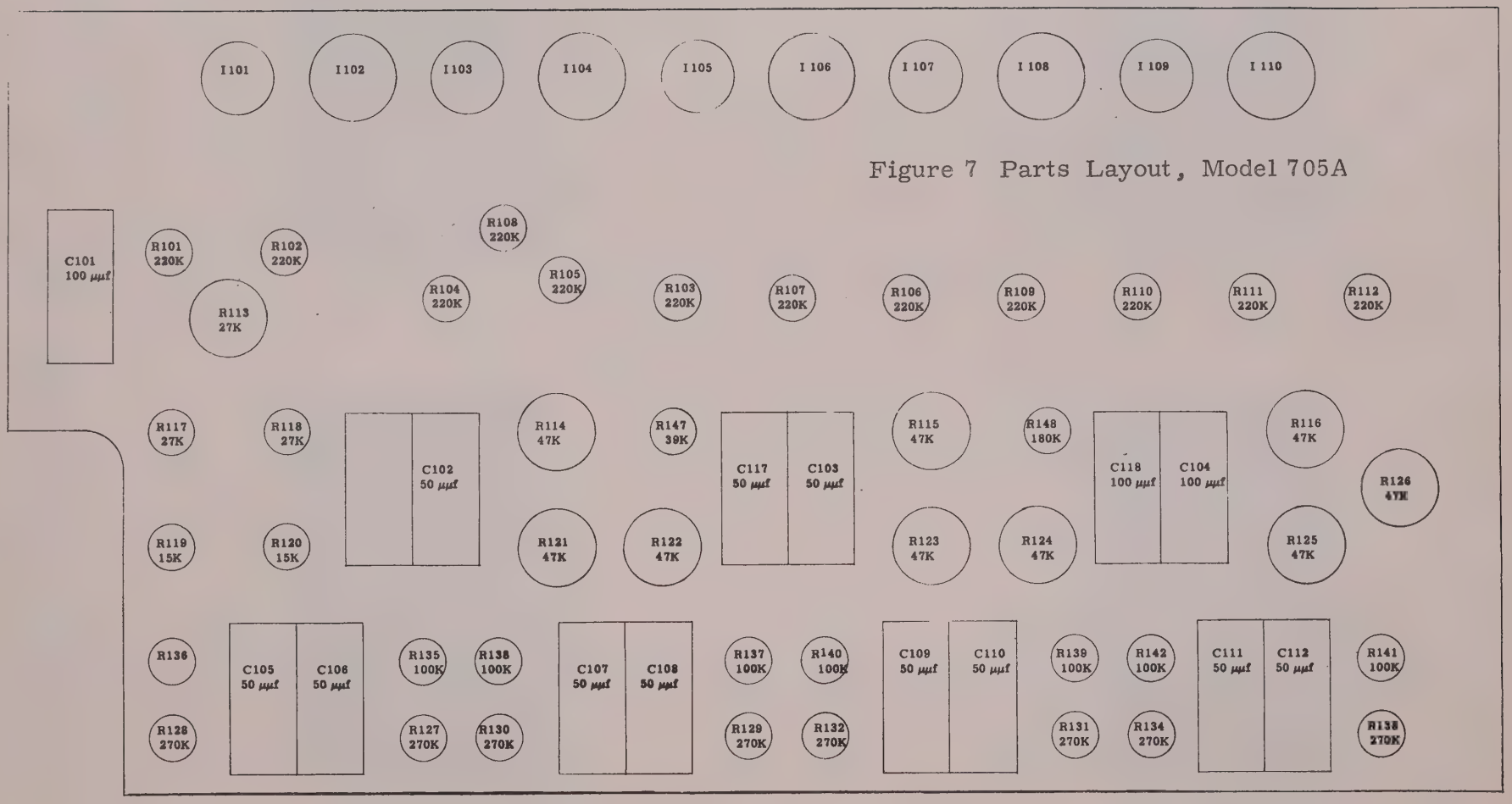
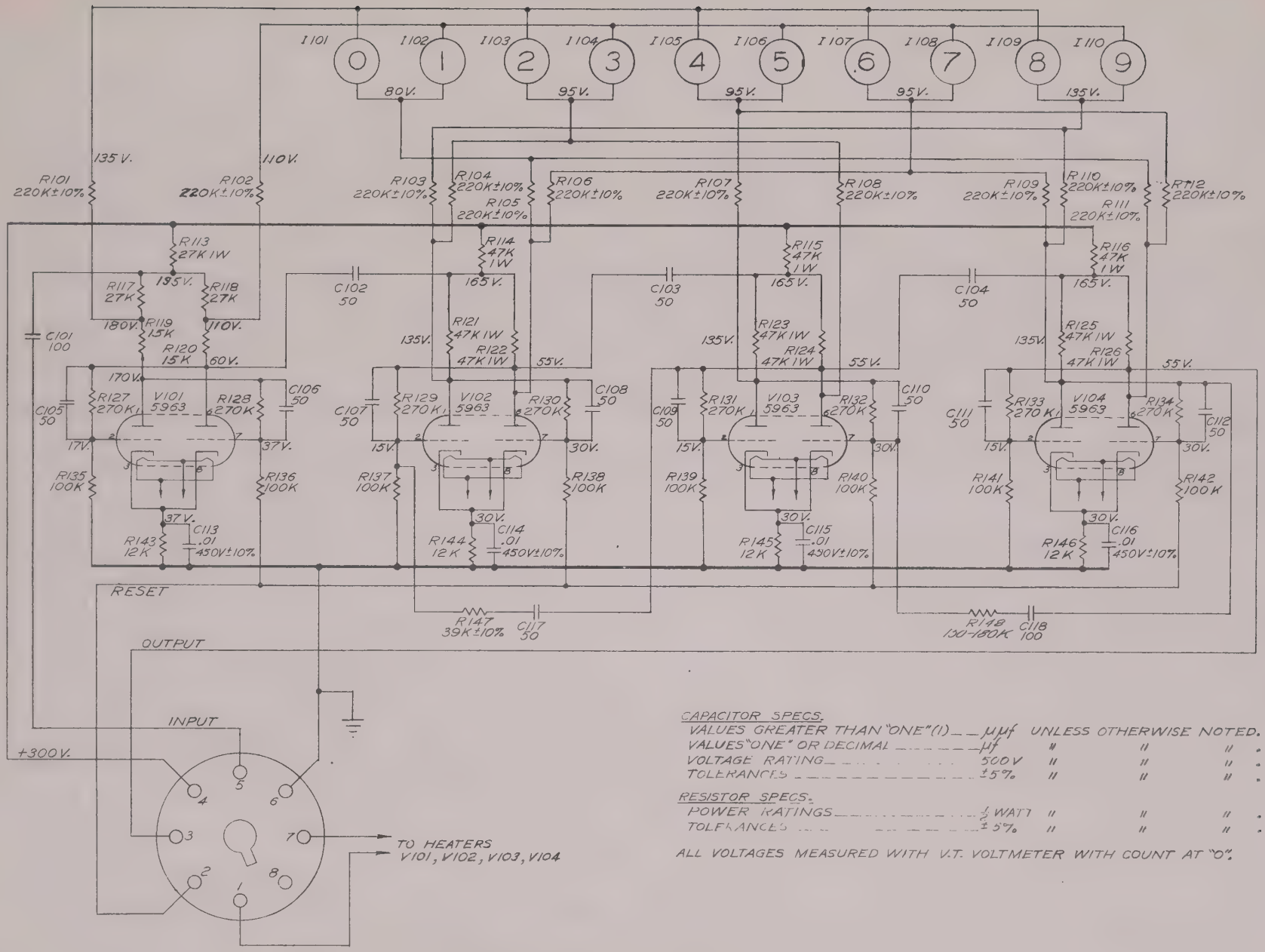


Figure 7 Parts Layout, Model 705A



CAPACITOR SPECS.
VALUES GREATER THAN "ONE"(1) ___ μμf UNLESS OTHERWISE NOTED.
VALUES "ONE" OR DECIMAL ___ μf " " " .
VOLTAGE RATING ___ 500V " " " .
TOLERANCES ___ ±5% " " " .

RESISTOR SPECS.
POWER RATINGS ___ ½ WATT " " " .
TOLERANCES ___ ±5% " " " .

ALL VOLTAGES MEASURED WITH V.T. VOLTMETER WITH COUNT AT "0".

Figure 6 Schematic Diagram Model 705A

INSTRUCTION
MANUAL

Lot 6 and up
Appendix B

Model 707A
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
1 December 1953

CONTENTS

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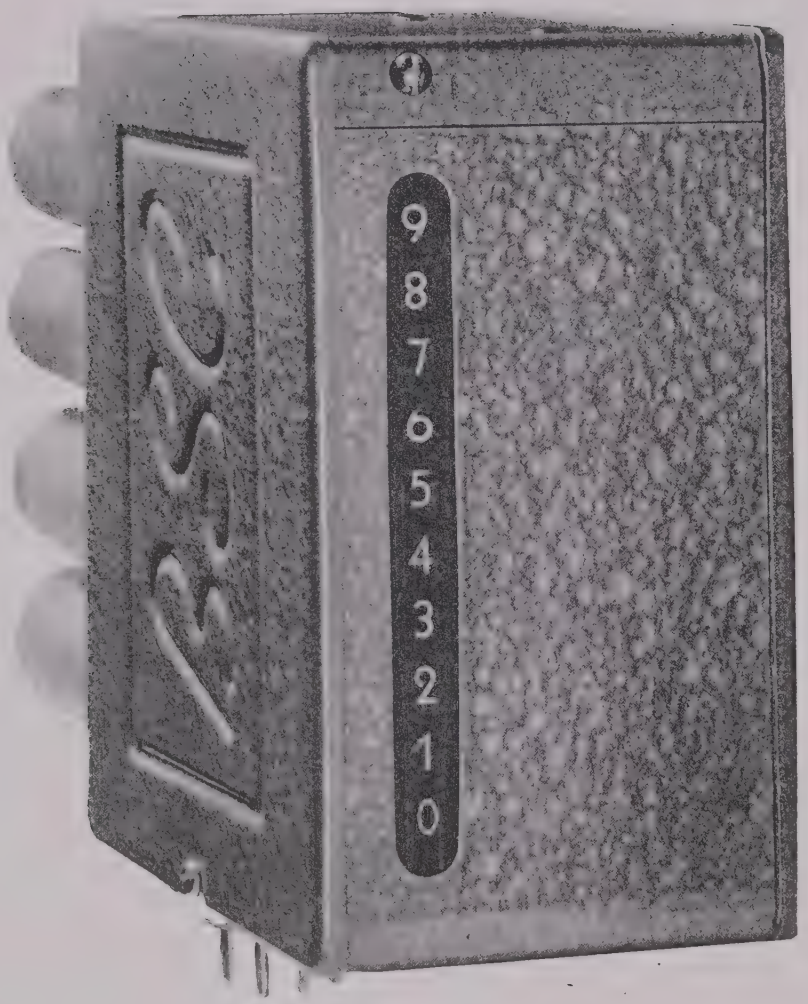


Figure 1 Model 707A Decimal Counting Unit

Section 1
INTRODUCTION

Description

The Model 707A Decimal Counting Unit is direct-reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. The maximum repetition rate of the input is one million counts per second. For random pulses the resolution is 0.8 microseconds.

The Model 707A will drive a Model 705A, which counts at a rate of 100,000 per second. The Model 705A will drive a Model 700A which has a maximum counting rate of 40,000 counts per second. This method of cascading is used to form a counter whose total capacity depends only on the number of DCUs used. Thus, six units will count to 999,999, resetting to 000,000 on the 100,000 pulse.

Specifications

Count Indication:	Direct reading decimal presentation
Power Requirements:	Heater: 6.3V at 3.6 A near ground potential 6.3V at 1.8 A near B+ Plates: 175 to 260 volts (nominal 225 at 60 ma)
Input Requirements Recommended:	Negative pulse 150 volt peak amplitude
Rise Time:	Less than 0.15 μsec.
Duration:	0.4 μsec.
Output Characteristics:	Designed to drive a 707A or 705A
Resolution of Paired Pulses:	0.8 μseconds
Reset to Zero:	Instantaneous through opening of grid return
Maximum Counting Rate:	1,000,000 cps

Construction:	Plug-in unit octal socket
Dimensions:	3" X 5-5/8" X 5-3/8"
Weight:	1-1/2 pound
Tubes:	6 each 6AL5; 4 each 5687

Section 2
OPERATION

Installation

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Operation

Power requirements:

Plate:	175 to 260 volts (nominal 225 at 60 ma)
Filament:	6.3 volts at 3.6 amps near ground potential 6.3 volts at 1.8 amps near B+ potential

Input requirements:

For optimum operation, drive the unit from a pentode, such as a 6AS6 or 6AU6, whose plate is directly connected to the input of the unit, thereby using the first stage of the DCU as the pentode plate load. A negative transient of 150 volts peak amplitude negative with respect to B+ is required to trigger the unit. The rise time should be less than 0.15 microseconds, and the duration at least 0.4 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the supply. If condenser coupling is used to the input diode, the cathodes should be connected through a resistor to B+.

Output requirements:

The output is a rectangular waveform as shown in Figure 4. It is represented at the output terminal as a change in direct current voltage level. Between counts of "0" to "4" it is 90 volts; "4" to "6", 150 volts, and "6" to "9", 180 volts. The load imposed on a unit must not be more than 100,000 ohms to ground, or a 5,000 ohm resistor with a 100 $\mu\mu$f capacitor to ground.

Regardless of the number of units, all may be set back to zero by momentarily opening the ground connection to a common line connected to pin 3 of the 11-pin socket. Care must be taken to avoid coupling voltage surges into the input or power supply circuits, otherwise they may not remain at zero upon reconnecting to ground. If a pulse is used to reset the unit, it should be 50 volts positive and at least 5 microseconds in duration.

Section 3
THEORY OF OPERATION

The basic circuit of the Model 707A is a modification of the Eccles-Jordan Trigger Circuit having two stable states, known as a binary. The type of binary used is shown in Figure 2. It is a two-stage amplifier with the output of the second stage connected to the input of the first. With no input, the loop gain is less than one, and the circuit is in one of its two stable states, i.e., either V1 conducting and V2 cut-off, or V1 cut-off and V2 conducting. The circuit is triggered from one state to the other by making the loop gain greater than one.

The binary is coupled to a single trigger source through the coupling diodes V3 and V4. If the input signal voltage has a steady value equal to B+, neither diode is conducting, since the potential of the plates of the diodes is either less than or equal to that of their cathodes. Assume that V2 is conducting and V1 is cut-off. If a negative pulse is applied to the input, V3 will conduct. Since its resistance is small compared to that of R1, the plate of V1 is driven negative. This drives the grid of V2 negative through the crossover network R6, R7, C2 and the grid-to-ground capacity of V2.

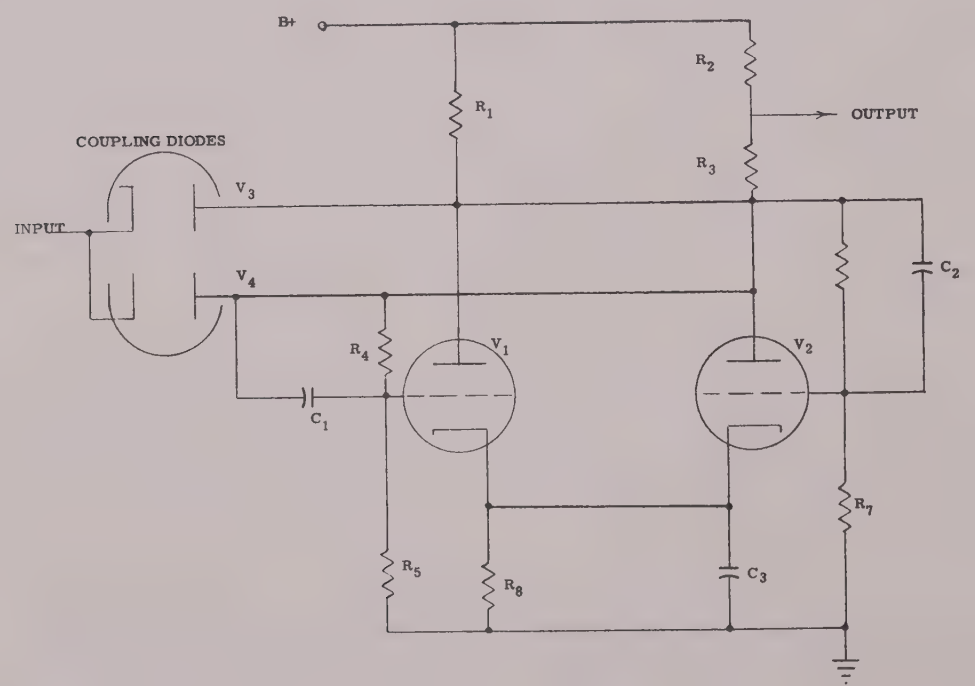


Figure 2 Basic Circuit

When the input pulse amplitude is sufficient, the loop gain of the binary becomes greater than one and it is triggered to its other stable state, i.e., V1 conducting and V2 cut-off. The next input causes the binary to return to its original state. It is seen that the binary is made to cycle once for two input triggers and is a scale-of-2. A counter having a scale of any power of two can be obtained by connecting binaries in cascade.

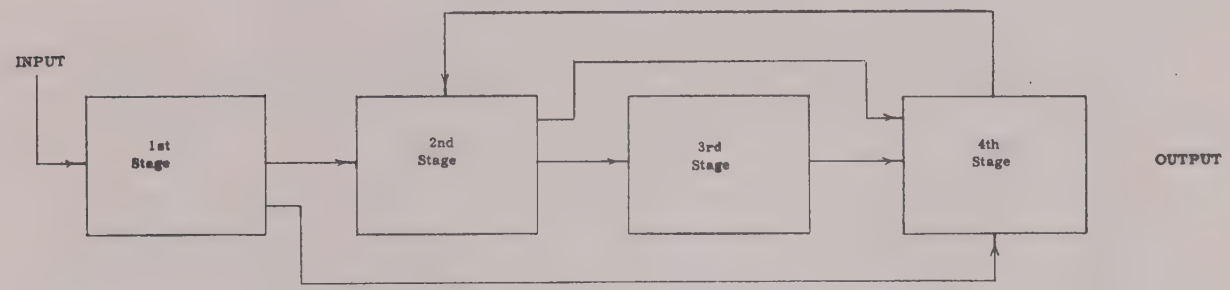


Figure 3 Functional Diagram, Model 707A

In the Model 707A, four binaries are connected in cascade, making a scale-of-16, which is permuted to a scale-of-10 by three diodes (see Figure 3). Two of these diodes are used as clamps and the third for coupling. The coupling diode is used to drive the fourth stage in one direction from the first stage. The diode clamps hold the off stage of a given binary to a voltage low enough that it cannot be driven by the preceeding stage. In the reset position, one diode clamp holds the fourth stage so that it cannot be driven by the coupling diode from the first stage. On the count of 2, the second stage is driven by the first stage, releasing the clamp on the fourth stage, and the second stage is then clamped by another diode from the fourth stage, so that it cannot be driven by the first stage. On the count of 4, the first stage drives the fourth stage releasing the clamp on the second stage. The state of the four binaries at this point is the same as the count of 10 in a scale-of-16. The clamping and driving the fourth stage from the first has the effect of adding six additional counts on the fourth input pulse. The scaler counts as a conventional binary counter for the remaining six input pulses. The adding of six counts on the fourth input pulse converts the scale-of-16 to a scale-of-10. Decimal indication is obtained by connecting ten neon lamps to the unit through a resistor matrix (see Figure 6).

Section 4
MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit of in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Diagrams and Tables

Typical waveforms are shown in Figure 4. By comparing these with the waveforms from a defective unit, the faulty stage can be quickly detected. Table 2 lists the voltages and resistances between tube socket connections and ground so that, in conjunction with the schematics and parts location diagrams, all information necessary to maintain the equipment in proper working order is available. It should be remembered that the values given are nominal, and considerable variations may be encountered owing to various line voltage conditions and component tolerances.

Circuit drawings and parts location diagrams will be found at the rear of the manual. The voltages shown were obtained with a vacuum tube voltmeter, a supply voltage of 300 volts, and measured between ground and the point indicated. The unit must be reset to zero to obtain the value shown.

Table 1
COMMON TROUBLES*

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First stage inoperative (V107)
Unit counts spuriously	(a) Stray input signal (b) Pulses received through power supply (c) External voltages picked up by output lead
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Unit skips every other number.	(a) First stage defective (V107) (b) Input circuit supplies double pulses
2. Two stable states per cycle.	(a) Count is 45-45 (resets to 2). The first cycle after reset is 2345 and the remaining ones are 45). V108 defective. (b) Count is 01-01 (resets to 0). V108 defective. (c) Count is 23-23 (resets to 0). The first cycle after reset is 0123 and the remaining ones are 23). V110 or V105 defective. (d) Count is 45-45 (resets to 0). The first cycle after reset is 012345 and the remaining ones are 45. V103 defective.

* Reset unit before troubleshooting.

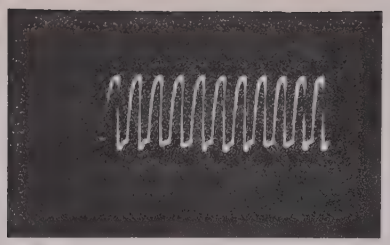
3.	Four stable states per cycle.	(a) Count is 6789 (resets to 6). V109 defective. (b) Count is $\overset{01}{45}$ 45 - $\overset{01}{45}$ 45 (resets to $\overset{0}{4}$). V109 defective. (c) Count is $\overset{0}{4}$145 - $\overset{0}{4}$ 145 (resets to 0). The first cycle after reset is 012345 and the remaining ones are $\overset{0}{4}$ 145). V104 defective. (d) Count is 6789 (resets to 0. The first cycle after reset is 0123456789 and the remaining ones are 6789). V104 defective.
4.	Eight stable states per cycle, that is, the pattern of lighting is repeated for every eight input pulses. It is possible to have more than one lamp ON for one or more of these states if there are eight distinct states per cycle.	(a) Count is $\overset{01}{45}$ 456789 - $\overset{01}{45}$ 456789 (resets to "0" but "4" on while reset switch is open. V110 defective. (b) Count is 01456789-01456789 (reset to "0"). V105 defective. (c) Count is 01236789-01236789 (reset to "0"). V106 defective. (d) Count is $\overset{01}{45}$ 456789 (reset to "0". The first cycle after reset is 0123456789 and the remaining ones are $\overset{01}{45}$ 456789. V106 defective.
5.	More than ten stable states per cycle as observed on an oscilloscope.	(a) Input pulse amplitude too small (b) Marginal tube in any stage
6.	Unit scales correctly as observed on an oscilloscope, but lighting pattern is 13579 at high frequency and at a slow repetition rate. (No light on reset)	(a) V101 defective
7.	Unit scales correctly as observed on an oscilloscope but lighting pattern is 02468 at high frequency and at a slow repetition rate (resets at 0).	(a) V101 defective

Table 2

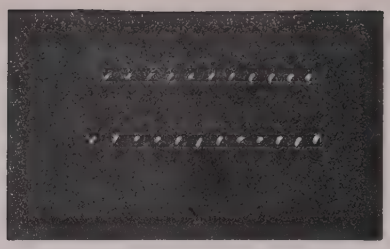
MODEL 707A - VOLTAGES & RESISTANCES

Tube	Pin No.	D. C. Voltage to Ground	Resistance to Ground (in ohms)
V107	1	200	14K
	2	33	12K
	3, 6	60	3.3K
	4, 5, 8	Filaments	
	7	60	12K
	9	110	14K
V108	1	140	21K
	2	20	18K
	3, 6	38	3.9K
	4, 5, 8	Filaments	
	7	39	18K
	9	70	21K
V109	1	150	21K
	2	15	18K
	3, 6	36	3.9K
	4, 5, 8	Filaments	
	7	37	18K
	9	55	21K
V110	1	140	22K
	2	15	18K
	3, 6	35	3.9K
	4, 5, 8	Filaments	
	7	35	18K
	9	55	22K

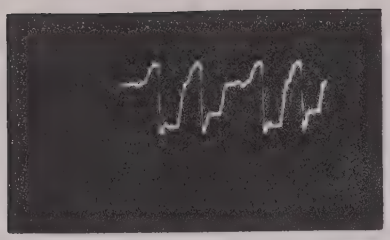
Note: B+ 225V
Pins 3 & 8 tied together



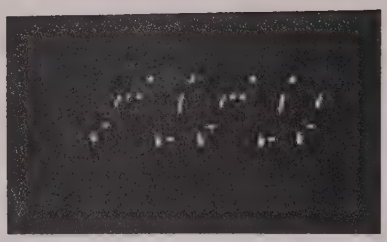
A. First stage, Pin 9, V107, UVL + 205, LVL + 110, frequency 500Kc.



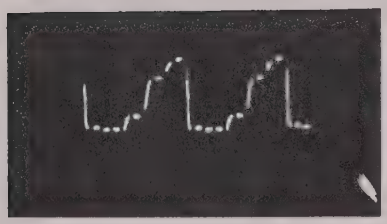
B. Same waveform blanked.



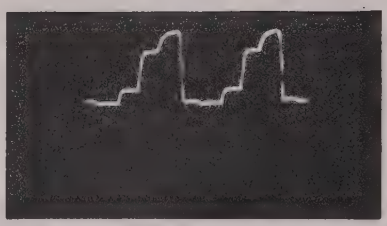
C. Second stage, Pin 9, V108, UVL + 180, LVL + 65, step at + 145, frequency 500Kc.



D. Same waveform blanked.



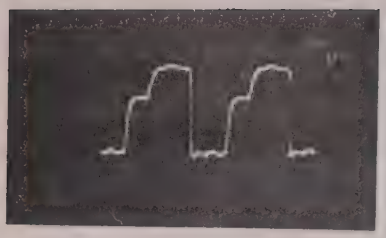
E. Third stage, Pin 9, V109, UVL + 180, LVL + 65, step at + 145, frequency 500Kc.



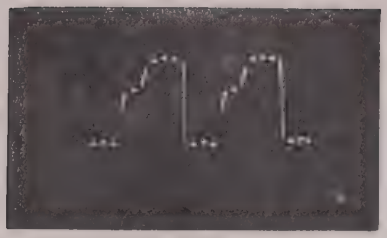
F. Same waveform blanked.

Note: UVL = upper voltage level
LVL = lower voltage level

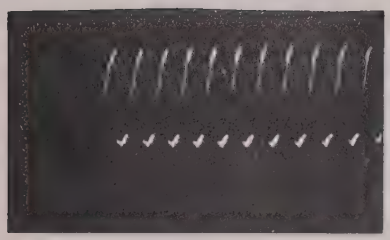
Figure 4 Typical Waveforms



G. Fourth stage, Pin 9, V110, UVL + 180, LVL + 65, step at + 145, frequency 500Kc.

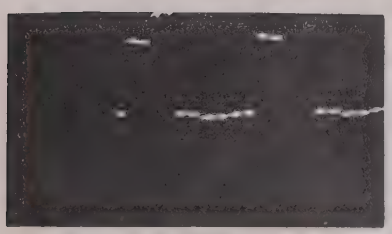


H. Same waveform blanked.

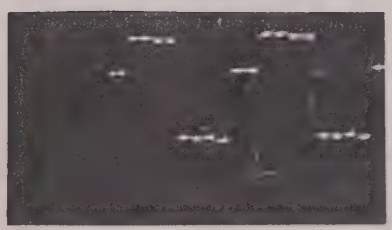


I. First stage, Pin 9, V107, UVL + 205, LVL + 110, frequency 100Kc, (blanked).

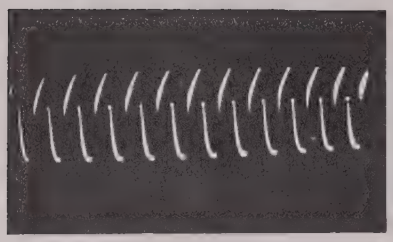
J. Second stage, Pin 9, V108, UVL + 180, LVL + 65, step at + 145, frequency 100Kc (blanked).



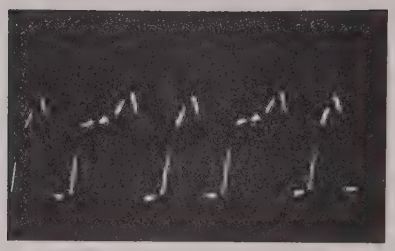
K. Third stage, Pin 9, V109, UVL + 180, UVL + 65, step at + 145, frequency 100Kc, (blanked)



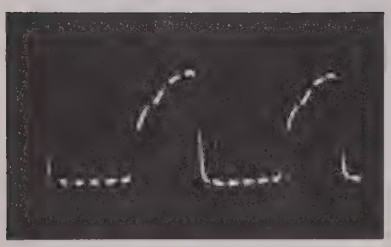
L. Fourth stage, Pin 9, V110, UVL + 180, UVL + 65, step at + 145, frequency 100 Kc., (blanked).



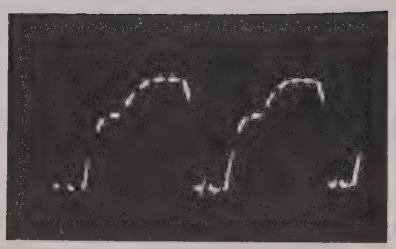
M. First stage, Pin 9, V107, UVL + 190, LVL + 105, frequency 1 Mc. (blanked).



N. Second stage, Pin 9, V108, UVL + 180, LVL + 65, step at + 145, frequency 1 Mc. (blanked).



O. Third stage, Pin 9, V109, UVL + 180, LVL + 65, step at + 145, frequency 1 Mc. (blanked).



P. Fourth stage, Pin 9, V110, UVL + 180, LVL + 65, step at + 145, frequency 1 Mc. (blanked).

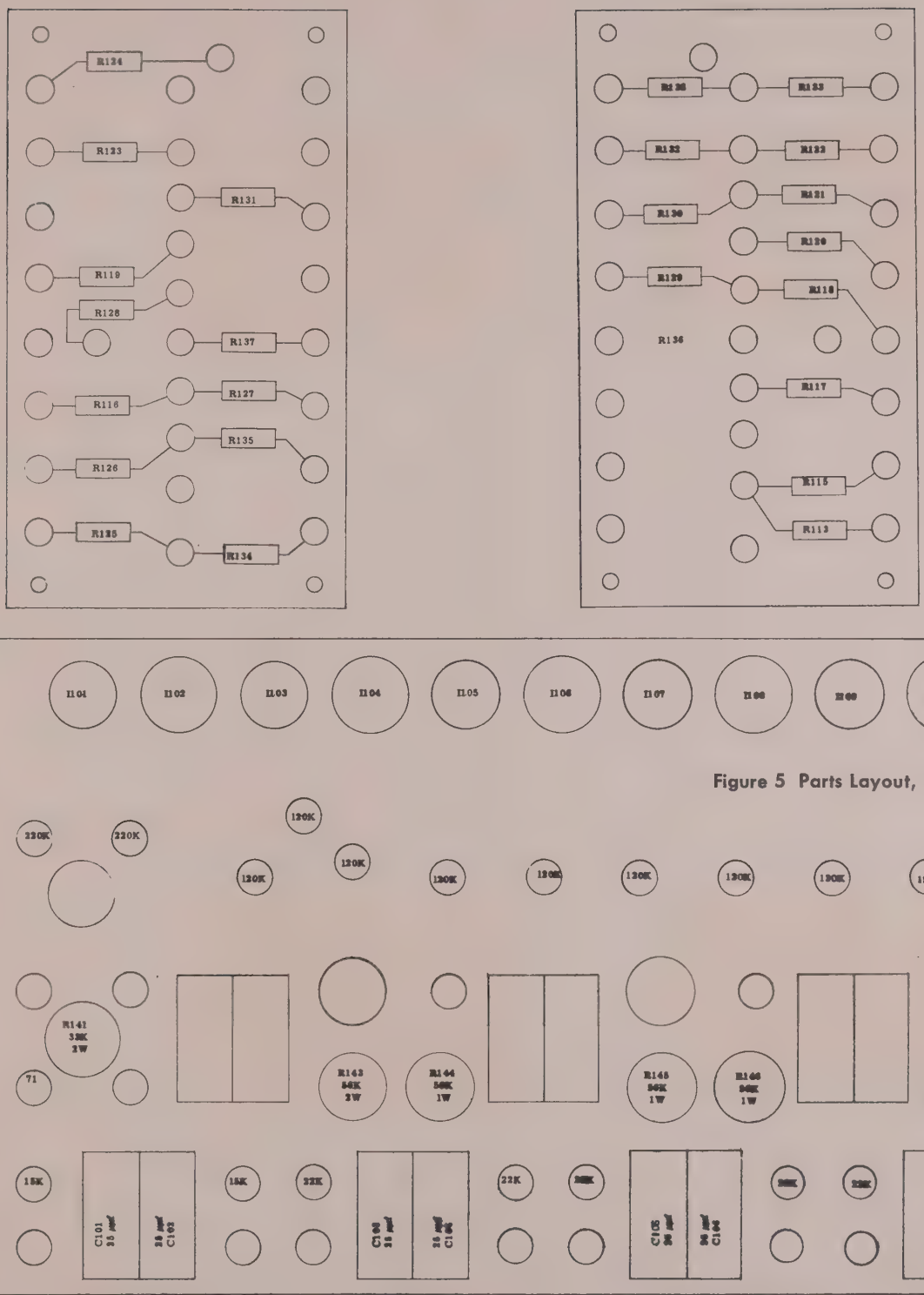
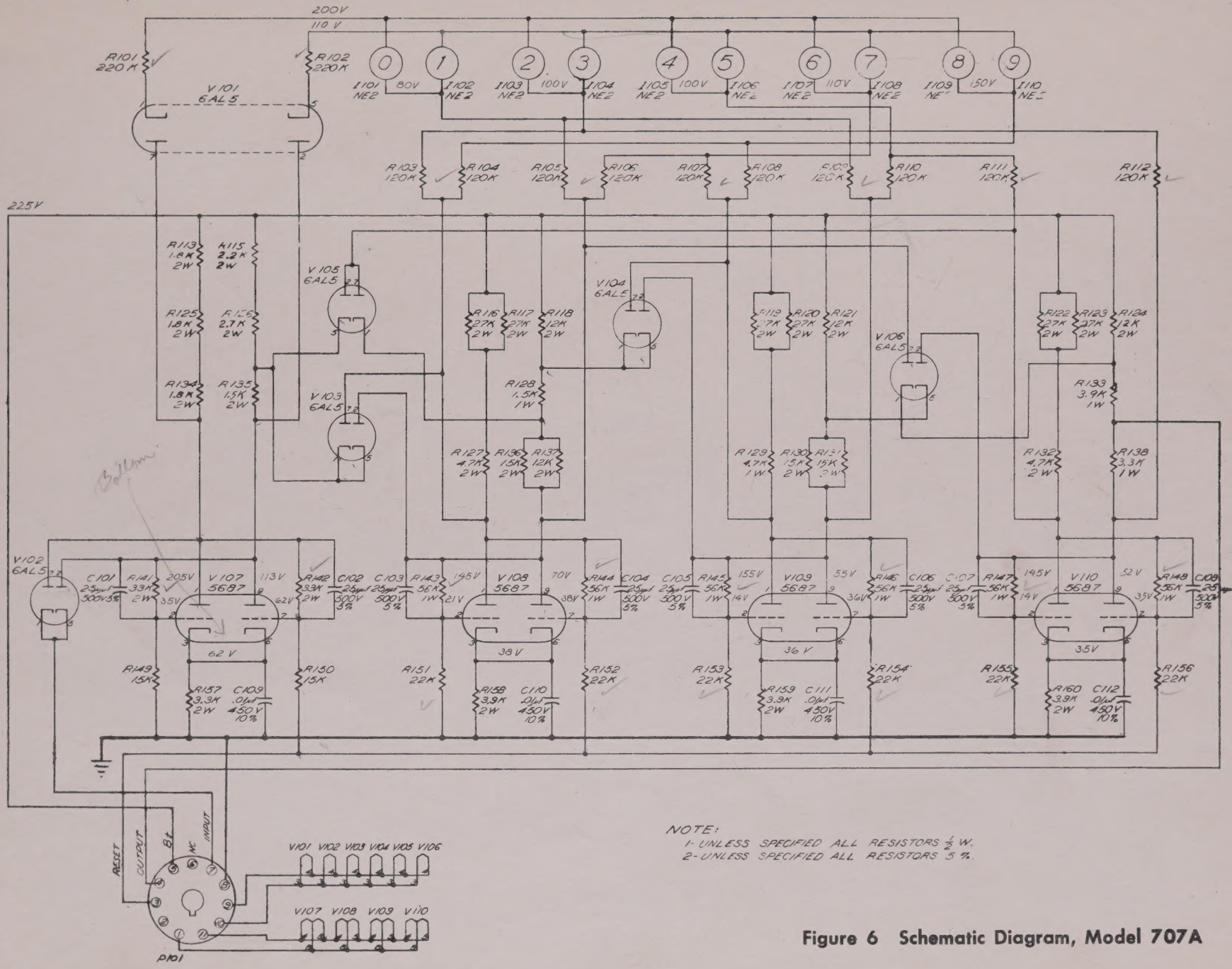


Figure 5 Parts Layout, Model 707A



NOTE:
1- UNLESS SPECIFIED ALL RESISTORS ½ W.
2- UNLESS SPECIFIED ALL RESISTORS 5 %.

Figure 6 Schematic Diagram, Model 707A

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